INTEGRATING BUILDING INFORMATION MODELING TO PROJECT MANAGEMENT CONSULTANTS' ROLE AND PRACTICE IN UAE

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A DOCTORAL THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF DOCTOR OF PHILOSOPHY IN CONSTRUCTION PROJECT MANAGEMENT

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ABSTRACT

The study sought to understand and systematically define how the Building Information Management (BIM) can be integrated into the Project Management Consultant's (PMC) role and practice in the construction industry of the UAE. To achieve this goal, the study first explored the global construction industry's performance, PMC roles and BIM standards. Several issues were identified in the Construction Industry ranging from the lack of satisfaction of clients, overall bad reputation of the industry, low profitability, lack of innovation and development and the dire need for lean construction and hence, change. As the Construction industry is a key player in the global economy and nations GDP, these issues need to be addressed and the overall functioning of the industry enhanced. As PMC is the primary stakeholder of the industry, the study then, utilizing semi-structured interviews with the BIM Managers of the various firms, tried to understand the current key practices and trends in the PMCs role in the UAE. Using this data and the data obtained from the global study, another round of semi-structured interviews was conducted which asked what the ideal functions of the PMC should be in line with the BIM stages. Using this information and the RIBA overlay of BIM, a new framework prototype of the PMCs functions with the BIM integration was developed. Thereafter, this framework was tested and validated using ten interviews. Finally, a systematic, detailed and applicable PMC function with BIM integration was developed. The final framework indicates that in the pre-design stage PMC roles include reviewing, editing and commenting on EIR and drafting the project BIM strategy; drafting BIM scope for designer and consultant; and reviewing BIM in designers' pre-qualifications. In the design stage, the relevant tasks include: reviewing and approving the designer's BXP; managing the BIM development process; managing BIM related parts of the contractor's tender process. The tasks for construction stage include: reviewing, commenting and approval of contractor's BXP; managing BIM process, practice and implementation during the execution stage of the project; and managing the coordination between internal and external stakeholders of the project. Lastly, PMC tasks for the close-out stage include: managing the process of handing over BIM deliverables. This research study has identified the optimal practices of the PMC within the BIM function; hence, it has created a new framework on which future research can be directed. In addition, with the practical application of this framework in the construction industry, the existing functions can be revamped in favor of enhanced practices thereby leading to performance enhancement of the entire construction industry of the UAE and subsequently the GCC.

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Contents

LIST OF ABBREVIATIONS

AEC: Architect, Engineering and Construction
AIA: American Institute of Architects
APM: Association of Project Management
BCA: Building and Construction Authority
BIM: Building Information Modeling
BS: British Standards
CAD: Computer Aided Design
CDE: Collaborative Data Environment
CIOB: Chartered Institute of Buildings
COBie: Construction Operations Building information exchange
DM: Dubai Municipality
EIR: Employees Information Requirements
ERP: Enterprise Resource Planning
GCC: Gulf Corporation Council
GDP: Gross Domestic Product
GIS: Geographic Information System
GSA: General Services Administration
ICT: Information and Communication Technology
IPD: Integrated Project Delivery
MCAA: Mechanical Contractors Association of America
NBS: National Building Specifications
NIST: National Institute of Standards and Technology
PAS: Publicly Accessible Standrads
PMC: Project Management Consultant
PMI: Project Management Institute
RIBA: Royal Institute of British Architects
UAE: United Arab Emirates
UK: United Kingdom (of Britain)
USA: United States of America

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CHAPTER 1

1 INTRODUCTION

1.1 Introduction

This chapter introduces the research work that is presented throughout the thesis. It provides a context for the study through background research on key issues in the construction sector, project management consultancy (PMC) profession and building information modelling (BIM). It also describes the research aim, objectives, methodology and provides an outline of the contents of the research.

1.2 Research background

The UAE construction sector is one of the most dynamic and fastest growing in the Middle East region. Since its poor performance after the global financial crisis in 2009, the sector has rebounded and experienced favourable growth levels driven mainly by investments in infrastructure, hospitality, retail and a range of other commercial projects (Cater, 2015). It is anticipated that spending in the sector will remain high due to activities such as Expo 2020 in Dubai and government infrastructure spending that is meant to help the local economy reduce its reliance on the hydrocarbons sector, which currently contributes 34.3 percent to the gross domestic product (GDP) (Jayaraman et al., 2016). The non-oil GDP is expected to grow by 2.5% in 2018 and by 2.8% in 2019 ("Growth in non-oil sector lifts UAE GDP", 2018).

Despite the anticipation of sustained growth levels, it can be noted that in general construction industry has been characterised by poor performance in comparison with other industries such as manufacturing (Wu et al., 2016). Among the key issues of concern include the significant number of construction projects that are not only marked by extensive delays but also substantial time and cost overruns (Doloi et al., 2012; Meng, 2012). The outcome is that an increasing number of clients in the construction are dissatisfied. High levels of dissatisfaction pose a threat to the industry since investors could look for alternative investments. Poor performance also comes at a time when construction projects are generally becoming more complex and difficult to manage.

In a bid to address the performance issues in the construction industry various researchers have investigated the most problematic areas and offered suggestions for improvement. One of the most notable initiatives was in the UK construction where Sir Egan in 1998 released a report called "Rethinking Construction" (Egan et al., 1998). Among the main highlights of the Egan, the report is that high levels of waste and inefficiencies mark the construction industry compared to other industries. Since its release, the Egan report has paved the way for extensive research and efforts in rethinking construction, developing ways of improving performance and tackling fragmentation. Three main areas and processes where improvement is necessary to have further being highlighted. First, there is a need to improve productivity, quality and cost deliverables through the use of a new process of lean, value management, supply chain management, re-engineering and use of performance indicators. Secondly, industry stakeholders need to take full advantage of IT and other new technologies. Thirdly, there is a need to develop people and cultural mindsets to facilitate progress in the above areas (Ball, 2014).

Project management consultancy (PMC) constitutes one of the key stakeholders in the construction industry that can significantly influence the sector's performance through application of technology in the provision of their professional services (Flanagan et al., 2013). PMC is defined as the client's advisor or representative who is responsible for leading, coordinating, supervising and managing all the organisations in a project to achieve the project's objectives (Kerzner, 2001; Meredith & Mantel, 2000). PMC has over the years become increasingly important as the traditional client-architect-contractor system becomes inadequate in terms of facilitating the completion of complex projects with cost budgets and time schedules. In the case of low performance of the PMC, there has been a rise in recognition of the importance of having someone to facilitate the management of construction projects as a client's representative.

PMC performs important roles in terms of solving issues related to design, contractor coordination, contractor coordination, construction issues and safety among others (Nitithamyong & Tan, 2007). In general, the key reason for appointing PMC to manage a construction project is to “ensure that a client’s needs, designs, specifications and relevant information are made available to and are executed as specified with due regard to cost by design team, consultants and contractors so that the client’s objectives are fully met” (Chartered Institute of Building, 2002, p. 95).

While taking into consideration, the use of IT and new technologies, one of the technological tools that can be used by PMC to improve performance in the construction industry pertains to building information modelling (BIM). Simply defined, BIM is an information production and management process that can be used to manage the construction process (Azhar, 2011) effectively. It has also been described in greater detail as computer software and diagrammatic modelling packages which are developed for multi-tasking the design, analysis, integration and enhancement of the construction project lifecycles (Kensek, 2014). In terms of benefits, BIM aids in the process of producing, communicating and analysing building models. This, in turn, assists in making the construction process more efficient, effective and interoperated (Eastman et al., 2011). Notably, the concept of BIM was introduced in the early 2000s as an enhancement of 2D object-oriented Computer Aided Design (CAD). Unlike CAD, the use of BIM allows for an integration of the ability to add informational ‘texture' of the designed objects in aspects such as properties and materials and hence a functional design (Ghaffarianhoseini et al., 2016). However, despite the efficiency of BIM, there is still a lack of wide acceptance in the UAE of the same. It could be attributed to incoherence in the role of PMC, and the disparities present hiring of the PMC at various stages of the project. This study will, hence, attempt to bridge the gap in the understanding of the role of PMC with an overlay of BIM tasks and functions.

Since its inception, BIM has gained popularity in various parts of the world. The UK government has, for example, made it mandatory government construction related projects to make use of BIM (Love et al., 2014). In the UAE similar efforts are being made. The Dubai Municipality (DM) has for instance being issuing circulars pertaining to the use of BIM across construction projects in Dubai. Buildings that are above 20 floors and compounds larger than 200 thousand square foot are now required to make use of the first stage of BIM. For buildings with over 40 floors and 300 thousand square feet, the use of BIM stage 2 is mandatory (Bhatia, 2015). However, use of BIM outside of the Emirate of Dubai remains optional. Notwithstanding, recent research in UAE indicates that BIM awareness is increasing with over 70% of the industry players indicating that within 5 to 10 years use of BIM will be highly popular (Mehran, 2016). The use of BIM has in this context being encouraged in the UAE construction industry due to its substantial benefits. These include lowering of the costs of the construction projects, better management of time and improved coordination between the various stakeholders (Eastman et al., 2011).

As the use of BIM becomes increasingly popular in the UAE, it will be necessary for PMC to adopt greater levels of use of BIM in undertaking their consultancy roles.

The contribution of this research, in academia, will be to create knowledge of how BIM can be integrated into the PMC's role to drive efficiency in construction management. There framework created and proposed in this study is the first of its kind, and further research will be required. Therefore, in addition to creating new information, this study will also serve as an impetus for future work.

This research will also have a practical application which will allow the construction industry and its various sub-specialties to increasingly adopt the BIM plan with a streamlined PMC function in the UAE. Hence, a study such as this could have a direct influence on the performance improvement of the construction sector in the UAE and across the globe.

1.3 Research Rationale

The performance of the construction industry in terms of efficiency and client satisfaction has been low ion comparison to other sectors. Across the world, the BIM standards vary and there is no clear adherence to an agreement of the PMC's tasks. There is a discrepancy in what the role of the PMC is and what it should be. There is also a disparity between when the PMC is involved during the project across various projects. It's posited that this leads to an inefficient working system which is bound to cause stakeholder (internal and external) discontent and the leads to wastage of resources (time, financial, and manpower). Hence, the rationale of conducting this study is to identify a way to integrate the PMC's tasks into BIM and hence drive up the performance of the construction projects and industry as a whole.

1.4 Aim and objectives of the research

The overall aim of this research is to enhance construction project management process by improving PMC's contribution to the BIM process management throughout project lifecycle. This same is achieved through formulating a BIM Management Framework which can enhances the PMC's function and streamline internal processes and functions of the Construction projects in the UAE.

Objectives

In order to accomplish the research aim, the following specific objectives will be pursued:

- To gain an understanding of the global construction industry performance and the PMC's role in construction industry.
- To develop clear insights into the evolution of BIM and practice in relation to the functions of the PMC.
- To investigate PMC's current functions, tasks and frameworks to identify best integration of BIM in the context of UAE construction industry through semi-structured interviews with identified key stakeholders.
- To develop and contextualize a holistic framework supporting the main PMC functions utilising BIM.
- To validate the proposed framework through interviews.

1.5 Methodology

In order to facilitate the application of the research findings in real construction projects, this research relies on empirical methods of data collection. Due to the lack of earlier research on the integration of the PMC role within the BIM framework, the research mainly relies on qualitative research. It should, however, be noted that qualitative data is often criticised on the basis that it tends to be subjective in nature. In order to overcome this limitation, some quantitative aspects of the study variables were also investigated such as the extent of the use of PMC in various phases of the construction project lifecycle. This data triangulation approach was meant to provide more robust findings. The following actions were undertaken during the research process in order to meet the aim and objectives highlighted in section 1.3.

In Stage 1 a detailed literature review was conducted with the aim of understanding the current knowledge and identifying possible gaps in relation to two key aspects. The first literature review covers construction performance and PMC role while the second one covers building information modelling.

Stage 2 involves data collection in two parts. The first part involves a collection of interview data on PMC functions and tasks as well as current practice in UAE. This data was obtained through semi-structured interviews held with industry experts. The second part of the data collection covers BIM current processes and limitations to PMC role. The relevant data in this part was also obtained through semi-structured interviews.

Stage 3 uses the data obtained in stage 2 to propose a framework for integrating BIM into the PMC role is drafted. The framework covers the key phases of the construction project lifecycle including pre-design, design, construction and closeout stages. Primary and subsidiary tasks for PMC role that is relevant to BIM management are discussed.

Stage 4 covers the validation and testing of the proposed framework. Three case studies are used for these purposes. In specific, BIM experts from three PMC organisations are involved in interviews that seek to establish the validity of the proposed framework in a BIM construction project setting as well as identify potential areas for modification.

Stage 5 involves the write up whereby the final framework is presented and discussed. Figure 1.1 summarises this research process.

The reason for choosing this research process is due to the lack of availability of data about the BIM standards in the UAE as it's not yet been fully integrated into the practice as it is in several other countries. The literature review provides an overview of the global practices, and the interviews provide an outline of what's happening and *not happening* in the UAE. This will allow us to develop a framework prototype which then will be tested or validated using case studies.

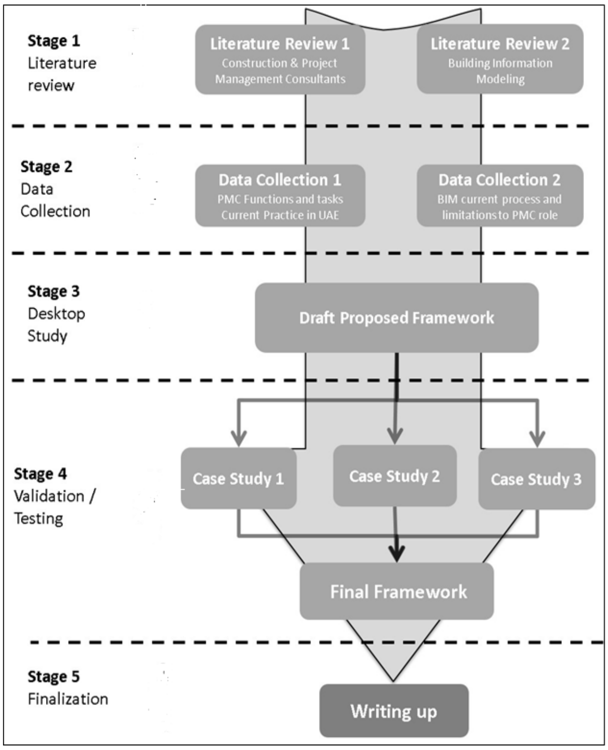


Figure 1.1: Research process

1.6 Thesis structure

This thesis is structured into seven chapters and appendices. A brief description of each chapter is provided below:

Chapter one – This chapter provides an introduction to the research which includes a background of the research, the aim and objectives and research methodology used in the study.

Chapter two – This chapter provides a review of the literature on performance in the construction industry as well as the evolution of the PMC role, its benefits and existing challenges

Chapter three – This chapter reviews literature on building information modelling including evolution and development of BIM, its benefits, current implementation and uses, current BIM standards and integration of BIM to RIBA plan of work.

Chapter four – This chapter provides the research methodology including the methods, approaches and adapted methodologies and justification.

Chapter five – In this chapter the data collected and used in the development of the framework is presented and analysed.

Chapter six – This chapter presents the proposed framework and case study validations.

Chapter seven – This chapter discusses the key findings from the analysis. Conclusions and recommendations for further research are also provided in this chapter.

1.7 Publications from this research

During the process of undertaking this research two papers were published. The first paper is a conference paper under the title

'**BIM for Project Management Consultants**'. The paper was presented in 3rd Urban Planning and Property Development conference in Singapore and was published in the conference proceedings with the following reference (Abu Ebeid, M. and Nielsen, Y. (2017). BIM for Project Management Consultants. In: *3rd Annual Conference on Urban Planning and Property Development*. Singapore: GSTF, pp.140-145.)

The second publication is a journal paper for the Journal of Engineering Technology under the title:

BIM Standards Around The World – A Review of BIM Standards in the Global AEC Industry and BIM Roles of Project Stakeholders. The paper was accepted with no comments for publication in GSTF Journal of Engineering Technology (JET) - (Print ISSN: 2251-3701, E-periodical: 2251-371X) issue: Vol.5 No.1.

Full papers are provided in the appendix. Appendix 1 contains the conference paper, and Appendix 2 contains the journal paper.

CHAPTER 2

CONSTRUCTION INDUSTRY AND PMC LITERATURE REVIEW

2.1 Introduction

The construction industry is considered one of the major drivers of the global economy. However, the industry has been suffering from poor performance in comparison to other industries, for instance, manufacturing. The poor performance of the construction industry has been the subject of discussion over the past century, and hence, substantial initiatives have been taken to address the poor performance. One of the leading examples of such initiatives came out of UK's construction industry is "Rethinking Construction" which was initiated in 1998 by Sir Egan in his famous, renowned report (Egan, 1998).

This part of the study reviews the evolution of construction industry, exploring current practices and poor performances within the industry as well as studying the solutions for lean construction and integrated project delivery (IPD) towards enhancing construction practice. It can be noted that during the evolution of the construction industry, new roles and players appeared to address the increased complexity of the construction projects. For this reason, this chapter also reviews the project management consultants' role evolution and their contribution to the construction industry and projects' performance.

2.2 Construction Industry Strategic Issues

Construction projects evolved through ages as humankind's needs have developed from simple shelters to modernised multipurpose buildings serving various needs and demands. The Stone Age humans made use of local materials to fulfil their shelter needs. Ancient Egyptians were among the first civilisations to build houses from sun-dried bricks with flat tops with the Royalty living in elaborate structures (Shelter, n.d.). The Assyrians discovered that baking the bricks in fire rather than sun-drying them made them harder and therefore, more durable. The Greeks had incorporated the usage of wood and other plant material in constructing their houses. Romans, however, introduced the concept of internal heating by laying down earthen pipes around the structure and running hot water through them thereby creating a primitive albeit efficient central heating system. The Chinese thereafter had complex structures which consisted of three separate components: the foundation, the frame and the roof which was often decorative. Around the Middle Ages, complex castles made out of stone started to appear. During this era, the structures began to increase in strength with brick foundations and timbered frames. The Early Modern period along with the Renaissance era brought with it an innovation in technology. Now, new and improved tools were available, and mass production of bricks started. The Industrial Revolution saw the creation of iron beams which were then used extensively in developing the support frames. Carpentry evolved and gave rise to complex structures made out wood. As the evolution continued, humans made more and more complex, strong and tall structures. These structures were not only used for shelter but also for other functions. Concrete, glass, iron, and alloys of other materials were used for the construction of strong, tall and sophisticated systems. Central heating systems and central air conditioning systems now became the norm of the modern, contemporary buildings. As the strength of the materials improved and new technology was made available, the structures grew taller and more complex.

The efficiency of the construction industry has fallen behind development through decades in other industries. There has been only a very minor increase in the productivity of the Construction industry labour productivity for the period between 1995 and 2014. It is showing a significant lag below the labour productivity as well the economy growth.

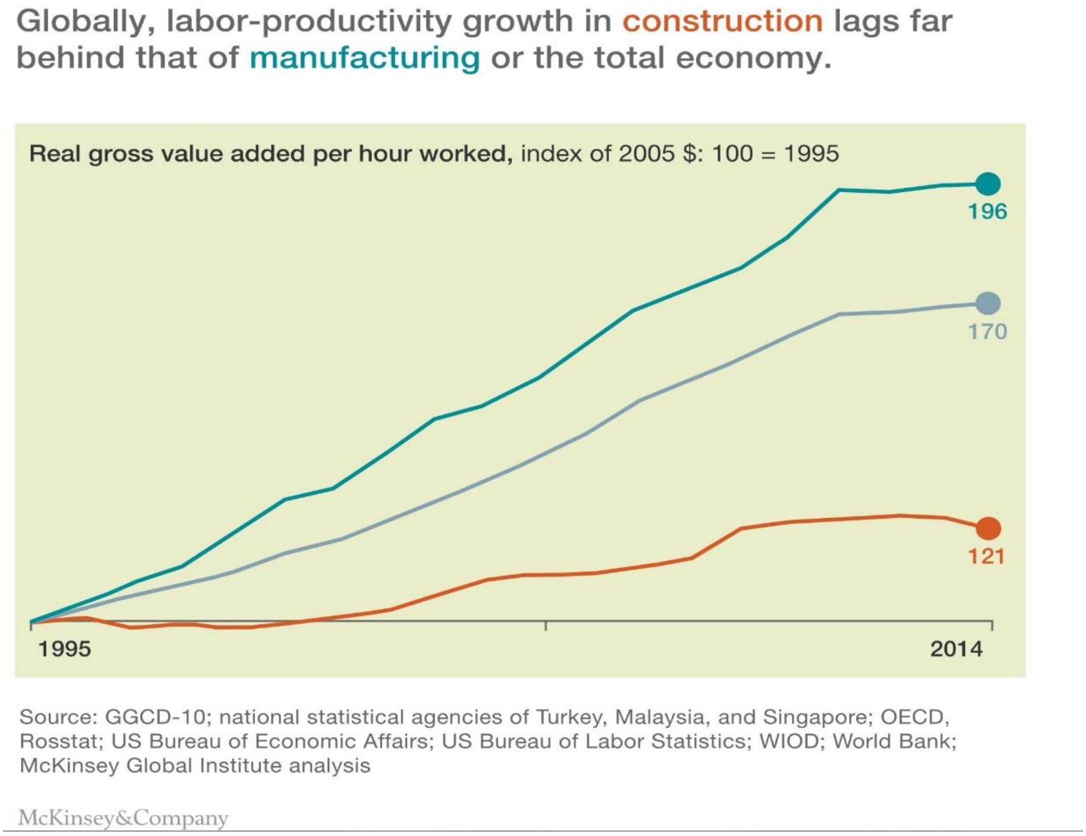


Figure 2.1 Labor productivity index in construction industry, 1995- 2014. Source: The McKinsey Global Institute (MGI's) Reinventing construction: A route to higher productivity report (2017).

According to the report published by McKinsey (2017), almost 70% of the construction projects globally have budget overruns, and around 61% have time overruns. The report outlined that this is due to several reasons including but not limited to the lack of investment in skills development and innovation, poor project management, inadequate personnel skills, and lack of efficiency in project management. Additionally, the report highlighted that there are substantial differences in the productivity levels of the construction industry at the global level. Due to the market being demand-led and informal, the issues of corruption have also contributed in the overall inefficiency of the global Construction Industry. In a case where the inefficiency continues to increase, the global infrastructure demand will be hard to meet. It is because of this inefficiency that performance issues have been the primary research focus for many stakeholders involved. These studies outline initiatives for the improvement of construction industry performance. Such research made it evident that the construction industry needs radical and strategic changes rather than short-term changes and ad-hoc solutions to overcome its challenges and problems.

Over the recent decades, the UK Government has conducted numerous investigations and studies for the construction industry and its poor performance. Some of the most comprehensive investigations were the ones made by Latham and Egan.

Egans' report Rethinking Construction (1998) investigated the lack of performance within the construction industry. The report concluded that the industry is suffering from major five problems which need to be addressed:

a) Construction Industry clients not satisfied (Cost, Time and Quality)

- Over 70% of the projects are over time or over budget

- Over 30% of the clients are dissatisfied with contractors' performance in keeping the project within coated price and time, resolving defect and deliver the product up to quality expectations.

More than 30% of clients are dissatisfied with consultants' performance for coordination, provide value for money and design innovation.

b) The delivery team not satisfied

This mainly caused due to bad working conditions, bad health and safety record (second worst of any industry), job security and wages, frequent mobilisation, and bad carrier development. All of these reasons together made the industry less attractive especially for younger generations.

c) Industry's Bad Reputation

The industry is known for lack of performance, lack of innovation, lack of development, Cowboy builders, etc.

d) Low profitability

The industry is considered less attractive to invest as return on investment is not high and fast enough. There are various reasons for that including high competition, competitive tendering, client focus on cost rather than value and too much waste compared with other industries due to the inefficiency of the industry.

e) Lack of Innovation and Development

The industry is often criticised by its' poor innovations comparing to other industries. Such judgment caused due to various reasons: Lack of high technology in design and construction, lack of branding, the final products (buildings) are usually behind in terms of intelligence and value, the pace of development is slow, and the client leads demand in the industry.

More recent research indicates that the ideals highlighted by Egan (1998) as a way of enhancing success in the construction industry are yet to be satisfied. Similarly, the McKinsey (2017) report which has been discussed above has outlined similar issues as the Egan report did almost two decades ago. The primary issue in both the reports is the fact that there is low client satisfaction, lack of governance in the industry leading to corruption and other issues, low rates of profitability and lack of investment in research & development. The fact that over two decades ago the Construction Industry faced much of the same problems that it is facing today is disconcerting. Lack of innovation in the industry, widespread client dissatisfaction, low rates of profitability, and the bad reputation of the industry are all linked and cause a gross inefficiency that is prevalent in the industry. According to Mckinsey (2017), the construction Industry can catch up if it were to address key seven areas as outlined in the below figure 2.2.

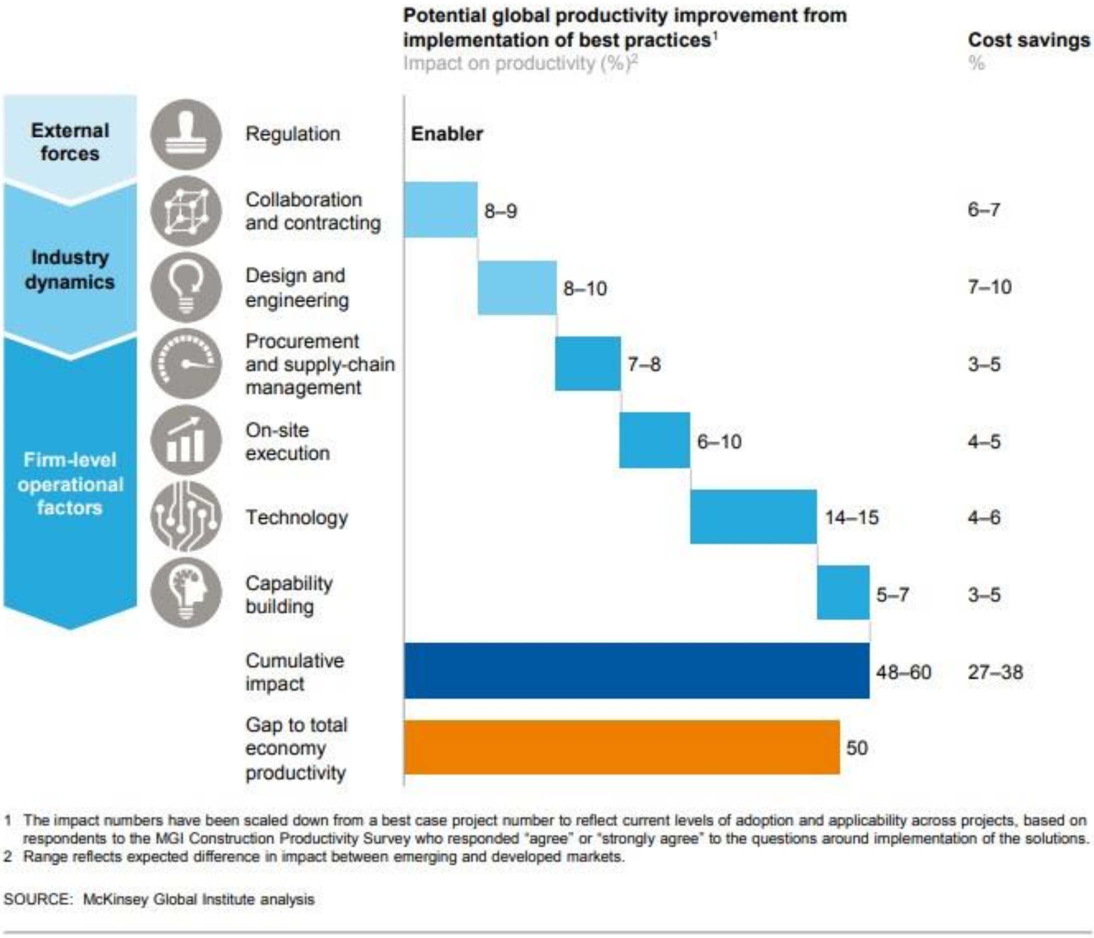


Figure 2.2: Potential improvement in the productivity of the Construction Industry, Source: McKinsey (2017)

With regard to client satisfaction, there is a general consensus among researchers that in a competitive industry like construction, achieving high levels of customer satisfaction is a crucial factor towards achieving sustainable competitive advantage (Kärnä & Junnonen, 2016; Bemelmans et al., 2015). Othman (2015) however highlights that construction project managers have continued with the tradition in which customers are excluded from the design and construction process. Client decisions are in this case made on their behalf by consultants and other project leaders. This approach has been criticised for the persistence of low customer satisfaction in the industry.

While most studies have attributed low client satisfaction to contractors, a few studies have suggested that several aspects often affect contractors and hence their inability to deliver the expected client value. Xiong et al. (2014) in a study of the Malaysian construction industry found that contractors face a variety of problems such as lack of client's clarity of objectives, lack of prompt payments, inadequate construction risk management and lack of effective collaboration, mutual respect and trust with other stakeholders such as project consultants. As such, client dissatisfaction could arise from low satisfaction from other key stakeholders such as project contractors.

Low profitability has remained a pertinent issue over the years. The research by Cain (2008) for instance indicates that most construction projects are characterised by unnecessary costs such as inefficient utilisation of materials and labour which constitute as high as 30% of the total cost of construction. This implies that significant amounts which could have been part of the company's profit margins go towards covering unnecessary costs. In the study by Cain (2008), it was further found that effective performance measurement which facilitates the location of unnecessary costs throughout the supply chain could help in substantially increase profits.

Egan's report highlighted how the construction industry invests much less in research, development and capital compared to other industries. The in-house research and development had fallen by 80% between 1981 and 1996. Moreover, capital investment decreased by two-thirds of what it was 20 years ago. Such lack of investment is dragging back the industry's ability to keep up-to-date with innovation in processes and technology. Innovation is defined as the real use of significant change and improvement in a process, product or system that is new to the organisation developing the change (Chinowsky & Songer, 2011).

Within the above context, current research indicates that the modern construction industry is still slow to adopt new technologies and innovations. Oesterreich and Teuteberg (2016) find that due to time and cost pressures faced by the industry most players have been hesitant to pay for new research or utilise new technologies in areas such as software usage, cloud adoption, data security. Innovation has been low despite growing awareness that technology as potentially effective solutions to the industry's major problems in aspects such as cost, time efficiency and accuracy (Gosselin et al., 2016; Fulford & Standing, 2014). While it is expected that information technology spending should be increasing, a 2016 construction technology report by the Mechanical Contractors Association of America (MCAA) indicated that spending was decreasing. However, on a more positive note, the report found that an increasing number of builders are making use of important technologies such as Building Information Modeling (BIM) and job site sensors and scanners (MCAA, 2016).

There are various characteristics of current construction practice. However, the one which is most important for the purpose of this research is that design and construction are mainly separate processes carried out by separate teams. Such practice has various consequences including not limited to longer duration than necessary as since design and construction do not overlap, inefficient design which might lead to higher construction cost and more complicated to execute, lack of trust and confidence between designers and contractors and finally a major constructability issues caused by lack of proper communication between designer and contractor.

2.3 The Need for Change/Lean Construction

The construction industry needs to start adapting solutions and innovation towards practice improvements. There are two of the best leading examples came out of US and UK's construction industries. The US initiative which been accomplished by The National Institute of Standards and Technology (NIST) focused on the additional cost sustained by building owners as a result of inadequate interoperability (Gallaher et al., 2004). The study covered the exchange and management of information on construction projects. The incompatibility of systems is affecting the ability to share information rapidly and efficiently between various individuals and stakeholders. Such a challenge causes numerous problems including not limited to additional cost and delays. The NIST study shows the inefficiency of interoperability affects cost in various phases of a construction project. The following table illustrates the findings of this study.

Stakeholder Group	Planning, Engineering, Design Phase	Construction Phase	O&M Phase	Total Added Cost
Architects and Engineers	$1,007.2	$147.0	$15.7	$1,169.8
General Contractors	$485.9	$1,265.3	$50.4	$1,801.6
Special Contractors and Suppliers	$442.4	$1,762.2		$2,204.6
Owners and Operators	$722.8	$898.0	$9,027.2	$1,0648.0
Total	**$2,658.3**	**$4,072.4**	**$9,093.3**	**$15,824.0**
Applicable sf in 2002	1.1 billion	1.1 billion	39 billion	n/a
Added cost/sf	**$2.42/sf**	**$3.70/sf**	**$0.23**	**n/a**

Table 2-1. Additional costs of inadequate interpretability in the construction industry. 2002 (In $M). Source: Table 6.1 NIST study (Gallaher et al., 2004)

Over 60% of these extra costs were incurred by the building owners. Although the findings of the study were speculative, it highlighted the significant lack of the current practice and raised the necessity of valiant actions towards overcoming the obstacles and avoid such findings.

Besides the NIST study, a number of other studies have highlighted key issues on interoperability that continue to impact the construction industry negatively. According to Frankston (2009), lack of interoperability disturbs the creation of collaborative work and networked systems in the organisation. The impact is that seamless cooperation between the various construction stakeholders is hindered. Similarly, Grilo and Jardim-Goncalves (2010) contend that in organisations where interoperability is lacking, productivity is greatly compromised through higher cost of transactions, low efficiency and quality, as well as longer yield times. In the specific case of the construction industry, Pyke and Madan (2013) found that the lack of interoperability makes it significantly difficult to achieve automation and further undermine the ability to draw important building inferences based on multiple datasets. While BIM seeks to help achieve interoperability in the construction industry it has also been faced with several problems such as the limited use of technology by constructors. Such technological limitations also increase the possibility that errors will occur. Shin (2017) also highlights that the use of BIM for purposes of interoperability also requires vast amounts of information which may not always be available.

The second major initiative by the UK government was the report "Rethinking Construction" which was initiated in 1998 by Sir Egan in his famous report (Egan, 1998). The report effectively highlighted the significant amount of waste in construction industry comparing to other industries like manufacturing, paving the way to the current extensive research and efforts in rethinking construction, developing ways of improving performance, and tackling fragmentation. Three processes are utilised in this area. The first combines improved productivity, quality and cost deliverables through the use of the new process of lean, value management, and supply chain, reengineering, and performance indications. The second process involves taking full advantage of IT and other new technology while the third entails developing people and culture to facilitate the first and second processes.

By definition, lean construction entails the application of a production management-based project delivery system that places emphasis on enhancing the reliability and speed of delivering value (Al-Amor, 2012). The philosophy largely borrows from the manufacturing industry where lean manufacturing was popularised by Japanese firms such as Toyota Motor

Company. Within this context, the use of lean approaches requires the project managers to focus on the maximisation of value and minimisation of waste while at the same time pursuing perfection (Koranda et al., 2012).

In the construction industry, lean project management is conceptually different from traditional project management not only in the goals that are pursued but also the structure of the different phases of the construction project and the relationship between the phases and participants in each phase (Ballard et al., 2007). In greater detail, lean construction emphasises the need for enhanced productivity. Such focus can be attributed to earlier research reports indicating that despite the emergence of new technology and sophisticated software the overall productivity of the construction industry has been characterised by a decline over the past five decades (Eastman et al., 2008). Accordingly, lean construction is considered as an approach that can be instrumental in helping the construction industry deliver the required projects while at the same time maximising value and minimising waste.

Many initiatives have been taken to adopt the outcomes of the report and innovate suitable solutions towards lean construction. Some of the innovative solutions were studying promising resolutions to improve construction productivity. According to Ballard and Howell (1998) "What Kind of Production in Construction", construction has two main characteristics which make it unique and different from other industries. The first is that it is under a fixed position manufacturing as assembling must be done on site. Second, the product is ingrained to place which means standardisation is limited and it falls under temporary teams.

However, to overcome the challenges produced by these characteristics, there are two main approaches should be adapted in order to make construction Lean. The first approach entails making the production of construction components lean and minimise site-based assembly and secondly developing lean techniques for dynamic construction (Ballard & Howell, 1998). As demonstrated above, the rationale for this research arises from the need to assist in strengthening the current practice for construction projects.

Several important perspectives on lean construction have been put forward in existing research. To start with, waste which is a key issue in the construction industry as highlighted in Egan's (1998) report has been classified into seven categories. These include waste in the form of defects, over-processing, excess materials, delays, unnecessary transport and conveyance of materials and unnecessary movement of people (Ballard & Howell, 2003). In terms of benefits, studies indicate that construction firms adopting lean construction can achieve up to 25 per cent cost reduction compared to using traditional approaches for project management (Pinch, 2005; Al-Aomar, 2012).

In addition to cost reduction through waste minimisation, lean construction has been seen as an effective way through which construction projects can achieve continuous improvement, strong user focus, improve communications and provide value for money (Ogunbiyi et al., 2014). Lean construction is also being increasingly considered as a potentially effective way of achieving sustainable construction. Studies by Ding (2008) and Nahmens and Ikuma (2011) for example found that application of lean approaches could enhance sustainability in the construction industry through better allocation of resources, construction of buildings with minimal energy consumption and facilitate the efficient and effective use of natural resources during the building process.

The implementation of lean construction management in the construction industry integrated with BIM could lead to increased productivity and sustainability. The development of an ideal BIM framework has the potential to enhance the interoperability of construction projects when coupled with lean construction management.

2.3.1 Integrated project delivery

Another key change that has been advocated for in the construction sector pertains to the need to embrace the concept of integrated project delivery (IPD). IPD is defined by the American Institute of Architects (AIA, 2007) as an approach to project delivery that seeks to integrate people, systems, business structures and practices into a process that can facilitate the effective hardness of the talents and insights of the various project stakeholders. The overall objective of IPD is to optimise project results, enhance value to the project client, reduce waste and maximise efficiency in all stages of the construction process (AIA, 2007). The concept is therefore closely related to lean construction.

IPD is different from the traditional approaches used in project delivery. It, for example, involves multi-party contracts, early involvement of key stakeholders, collaboration in decision making and control and the presence of shared risks and rewards among the project stakeholders (Sive, 2009). In terms of impact on project performance, IPD has been shown to enhance performance through more effective communication, better teamwork and the alignment of stakeholder interests with project objectives (Mesa et al., 2016). Sarkar and Mangrola (2016) also reported that early involvement which is one of the key aspects of IDP helps address the problem of fragmentation between design and construction professionals. Such fragmentation has been cited as responsible for inefficient work practices and well as the need to engage in late costly changes during the construction phase. In contemporary times, early involvement is facilitated by BIM through increased efficiency of collaboration throughout each of the project phases.

2.4 Evolution of Project Management Consultant's Role

Building Construction always was an interest for humankind for thousands of years which started by their demand for shelter and evolved to exceed that fundamental demand. Construction projects by nature are too large and complex for an individual to accomplish, therefore and consequently through time people developed approaches to collaborating on such endeavours.

Projects mainly comprise three main stages: planning, design and construction (Kymell, 2008; Weiler & Scholz-Barth, 2009). In middle ages of Western Europe, all tasks related to a construction project used to be accrued by a master builder who executed a project for the owner. The master builder was the designer, planner and executer at the same time. As projects became bigger, the team involved increased as well. The master builder was responsible for ensuring that builders on site are executing the building as per the owner's intention and his role was to instruct workers and manage them verbally. At that time there were no project documents as we know them today. This process limited the speed, size and scope of the projects although there is one advantage that one person who solves all problems managed the whole process. Prototypes of the building used to be done as a mock-ups onsite which was as the bases for the construction contract. Although this method was slow in general, it had an advantage of having one master builder mind that had a centralised point of control for the entire process (Kymell, 2008).

The increasing scale and complexity of the projects led to the sophistication of the role of the master builder. During the Renaissance era, the 2D drawings started to become the new way of communication between designer and site workers. Through years as the number of construction projects significantly increased after the renaissance period more construction projects were designed and planned in offices offsite and the 2D drawing became the primary tool of communication. Despite the increased use of 2D drawings at the time they were characterised by several difficulties in their use. Some of the common problems included the time-consuming nature of the 2D architectural scale model, difficulties in assessing concept design in relation to the building surrounding environment, low information integration and failure to provide adequate information for assessment of impact building aspects such as cost (Chantawit, 2005).

The more detailed drawings and documents were given to the builder who was responsible for executing the project on site. Kymmell (2008) noted that such a change in project management had a very large impact on the evolution of the construction industry. This change in the overall project management concept meant that a separate team should be on site to ensure that the process is ongoing as per design intention which split the master builder's role into two parts: Design and Supervision. Also, it meant that a separate party became the builder who is the contractor. As a result, the nature of the relationship between owner, designer, supervisor and contractor became more complex. The evolution of this complex communication among the project stakeholders became the construction documents known to us today, and it became paper documents. As the designer and contractor are separated, the number of unanticipated situations on site increased as well the need for answers.

The scope of the construction project increased significantly which consequently covered various disciplines of the trades such as mechanical, electrical and structural among others. This increased complexity which created the need for a party to act as a coordinator which evolved later on to be the Construction Manager (Kymell, 2008)

As construction projects' size and complexity kept increasing, the role of construction manager gradually evolved improvements to the overall process, and today there are various approaches of project delivery methods. It can also be noted that the need for better coordination of construction projects was evident from as early as 1980 when clients of construction projects increasingly lamented of poor performance in the AEC field. The clients demanded better quality, reduced cost and timely delivery of construction projects in both the private and public sectors (Touran et al., 2009).

It could be stipulated that the more sophisticated and complex the construction project became, the more human resources would be required to manage all the moving parts; so much so that it may have given rise to new professions. For example, the role of a Project Manager is indispensable in today's construction projects, but the first project management chart was created in 1917 by Henry Grantt. However, the modern project management and its various subspecialties did not begin until the 1950s when the American Association of Cost Engineers was formed (Haughey, 2014). Today, the complexity of the construction projects created the need for specialist organisations which provide project management services. This also could be linked to the evolution of construction management as a speciality and entire science is known as the Project Management Consultant (PMC).

2.5 PMC as a key player

Project Management Consultants (PMC) plays a driving role in managing complex contemporary construction projects. According to Flanagan et al. (2013), project management consultancy became an integral part of Construction Professional Services (CPS) which are produced by a combination of knowledgeable consultants including architects, engineers, planners, engineer-contractors, architect-engineers, engineer-architects and landscape architects. Therefore it is important for the following part of this research to have an understanding of PMC definition, role, uses and advantages for construction projects as well as challenges in the execution of the PMC roles.

2.5.1 PMC definitions

The Charted Institute of Builders defines PMC as “a client's advisor or representative who leads, coordinates, supervises, and manages all the organisations in a project in order to achieve the project's objectives" (Kerzner, 2001; Bennett, 1983; Meredith and Mantel, 2000). Also PMC is defined as the party who is being appointed by clients to “ensure that a client’s needs, designs, specifications, and relevant information are made available to, and are executed as specified with due regard to cost by the design team, consultants, and contractors (i.e., the project team), so that the client’s objectives are fully met” (Chartered Institute of Building, 2002, p. 95).

It is essential to highlight that different terminologies have been used in the previous studies bear some similarities to PMC. These terms include but not limited to "project management consultant", "client representative", "project manager", "consultant", "project consultant", "professional construction manager", and "construction supervising engineer" (Chartered Institute of Building, 2002; Royal Institution of Chartered Surveyors, 1996; Ceran and Dorman, 1995; Walker, 1998; Dainty et al., 2005; Liu et al., 2004; Jang and Lee, 1998; Barrie and Paulson, 1976).

Project management consultants have been referred to commonly in the construction professional services sector as the professional organisations and individual which provide a combination of skills and strategic and tactical solutions to the construction process. Their services are characterised by a "*framework*" of suitable disciplines and ethics, and decision-making on construction process in scientific, independent, and objective manners (Bowen, Pearl, & Akintoye, 2007). The wide range of consulting business requires that PMC is having multi-disciplinary knowledge and experience such as planning, construction technology, architecture, civil engineering, financial management, law, and regulations. The services of management consulting spread out along some established management procedures and techniques, which are generally described and could be tailored to satisfy different client's demands and project requirements.

In relation to the question of who should act as the PMC, existing research indicates that there are no hard and fast rules (Walker & Wing, 2000). In other words, depending on the procurement method to be adopted as well as the nature of the construction project, PMC could be selected from any of the key professional organisations/individuals such as construction management, architect, quantity surveying and project management. Sarda and Dewalkar (2016) however argue it is ideal that PMC be able to multitask and therefore experience in each of the key construction professions such as design engineering, construction engineering, construction management and project architecture is crucial. The ability to choose PMC from any of these disciplines has been attributed to an increase in flexibility of running construction projects (Ahuja et al., 2009).

The focus of PMC has evolved substantially over the years. During the 1980s PMC in its various identities such as client representative was dominated by an emphasis on planning and control tools. In addition, the consultants were keen on ensuring that project teams were professional in nature. This period was also dominated by a focus on the key project performance criteria which includes time, budget and functionality (Turner & Muller, 2006). During the 90s, it was observed that focus had gradually shifted to subjective factors such as customer satisfaction that had been largely ignored in the earlier years. The period was also marked by consultants depicting increased interest towards behavioural and interpersonal factors such as human resources. Such interest can be attributed to the realisation that human resources performed an instrumental role in the success of project management (Muller & Turner, 2007). Today, the consultancy has mainly been characterised by the need to enhance collaboration between project stakeholders and fulfilment of stakeholder requirements in the most effective and efficient way and hence the increasing application of innovative technologies (Muller & Jugdev, 2012).

2.5.2 Role and responsibilities of PMC

It is key for this study to have an understanding of PMC role and responsibilities and the necessity of their services for the clients. In a typical engagement, PMC is referred to as a client's representative or advisor who leads, manages, coordinates and supervises all the stakeholders in a project in order to achieve the client's project objectives (Bennett, 1983; Chartered Institute of Building, 2002; Kerzner, 2001; Meredith and Mantel, 2000). According to The Chartered Institute of Building (CIOB); the main tasks of PMC are:

- To make sure that client requirement, needs, design and specifications are available

- The project has been executed as required, designed and specified.

- Client objectives are fully met with cost and time respects (Chartered Institute of Building, 2002, p. 95).

It is commonly argued that the PMC roles could be compared to those of an “in-house project management team” performing typically by either the lead engineer or the architect of the project. However, there are still main differences in their roles. First, a PMC is commonly engaged in a complex and large project which requires various administrative skills and technical expertise for managing a large number of contracts, which are usually not available within architect or lead engineer in-house project management team. Second, a PMC is typically appointed on a project basis, and its appointment is typically ended when a project is completed. Third, and most important, a PMC only performs project management consultancy services and does not carry out any construction or design works with its own resources (Nitithamyong & Tan, 2007).

PMC roles and responsibilities have also been explained based on the total quality management perspective that seeks to achieve continuous improvement and waste reduction. The roles include preparation and organising, developing project definition, procurement, organising JMT, design management, safety management, measurement and review of performance, documentation and project post-mortem (Jawaharnesan & Price, 1997). Preparation and organising as a PMC role involve the assisting the client to set objectives, establish policies, develop an organisation structure and delegate authority and responsibility for the project. Once the client has established a need for the project it is the responsibility of PMC to assist in project definition through involvement of key participants such as construction professionals to establish specific project requirements, discuss constructability issues and convert the client's requirements into quality characteristics (Jawaharnesan & Price, 1997; Lindahl & Ryd, 2007).

In regard to procurement, the PMC role mainly revolves around ensuring that the chosen contractors and professionals can deliver the project in the most efficient way. PMC also organises a joint management team which in turn prepares an action plan for coordination, problem-solving and performance measurement of the project (Jawaharnesan & Price, 1997). Similarly, Ryd (2004) indicates that consultants perform an important role as facilitators in which case ensures that all parties involved in the delivery of the project work jointly. In relation to design management as a key phase of the construction process, PMC as the client's representative has a prominent role in terms of restating the client's brief in order to form detailed objectives. Some of the key aspects of the design management phase that PMC participates in include assessment of the constructability of the design and pre-qualifying of designers. Blyth and Worthington (2001) also indicate that the consultant should act as a design brief manager by ensuring that the construction manager has all the necessary information about the client's design preferences.

Safety management as another key role of PMC requires the individual or organisation to ensure that the project is undertaken in an accident-free environment (Langford et al., 2000; Jawaharnesan & Price, 1997). Accordingly, PMC is involved in the joint preparation of health and safety policy jointly with other project stakeholders. In relation to measurement and review of performance, one of the important roles performed by PMC pertains to monitoring the conformity of standards established at the planning stage of the project. It is also the role of PMC to ensure that causes of deviation from the set standards are investigated and removed through appropriate problem-solving techniques such as plan-do-check-act (P-D-C-A). While on the same context, Schwarz (2002) argues that the consultant performs an important role as a facilitator by ensuring all other parties act consistently and within the client's project targets as well as support the team throughout the project by facilitating problem-solving exercises.

The PMC role of documentation involves putting in place a systematic documentation procedure that allows for identification, collection, indexing, filing and maintenance of quality records (Jawaharnesan & Price, 1997). PMC, in this case, ascertains whether all documentation processes have been effectively undertaken. Lastly, on project post-mortem, PMC facilitates the process of uncovering the successes and failures of the construction project. The resultant reviews and discussion are used as a basis for uncovering future opportunities for improvement in other projects. Lindahl and Ryd (2007) while expounding on this role also indicate that besides iterating and validating the project goals, the consultant has the responsibility of thoroughly examining the outcomes of the completed project in order to help in future improvements.

In some cases, PMC has not always been effective in fulfilling its roles and objectives. Jawaharnesan and Price (1997) attribute such failure to the adoption of a traditional perspective to PMC. In the traditional perspective, PMC makes use of a reactive and confrontation approach in undertaking the set roles. For example, PMC was traditionally involved in inspecting, checking and ensuring that the project is being undertaken based on the set standards. The excessive focus on monitoring as opposed to helping the contractor improve performance means that PMC from the traditional perspective was mainly critical to the contractor's work. The impact is the presence of differing goals between PMC and the contractor which triggers disputes and conflicts. According to Chan and Kumaraswamy (1997), such disputes which often occasion project time overruns can be avoided by collaborating with the contractor to improve quality throughout the project rather than only participating in monitoring or inspection. A more recent study by Sandra and Dewalker (2016) also argues that besides project monitoring and control, PMC should perform a critical role in providing effective measures to improve the efficiency of the project.

2.5.3. Competencies of PMC

As Several competencies of project management officials were outlined by the Association for Project Management (APM): Ethics, Compliance, & Professionalism, Team Management, Conflict Management, Leadership, Procurement, Contract Management, Requirements Management, Solutions Development, Schedule Management, Resource Management, Budgeting & Cost Control, Risk and Issue Management, Quality Management, Consolidated Planning, Transition Management, Financial Management, Resource Capacity Planning, Governance Arrangements, Stakeholder & Communications Management, Frameworks and Methodologies, Reviews, Change Control, Independent Assurance, Business Case, Asset Allocation, Capability Development, and Benefits Management (APM Competence Framework, n.d.). Each of these competencies is measured on a scale of one to five with one representing awareness and five representing expertise. The competence and the performance of the project management official are measured along two criteria: application and knowledge.

On the other hand, the competence framework developed by Project Management Institute (PMI) comprise of: Initiating, Planning, Executing, Monitoring & Controlling, Closing, Communicating, Leading, Managing, Cognitive Ability, Effectiveness, and Professionalism (Cartwright & Yinger, 2007).

2.5.4 Benefits of PMC

After reviewing who PMC are and what is their role; there will be a necessity to evaluate their benefits towards the projects and their clients. This being a subject of many studies and researches conducted to evaluate the advantages and disadvantages of PMC. Many researches have discussed both advantages and disadvantages of engaging a PMC for construction projects such as researches by Kwakye (1997), Murdoch & Hughes (1996), Spinner (1997), Lam & Chan (1994) and Masterman (1992). These researches discussed the advantages and disadvantages of engaging a PMC from the client's perspective. There is a common advantage for engaging project management consultants concluded in most of those researches which are faster project delivery. However, and on the other hand, a common disadvantage for such engagement is the increased management fees.

The focus on the client in these studies is understood as commonly authors been trying to provide the information on procurement approach for different project characteristics. Wilkinson (2001) suggested that it is advantageous to engage a PMC for the construction project. The main advantages of such engagement are:

a) Provide clear leadership in a project
b) Reduce in-house conflicts and disputes
c) Offer non-vested interest advice.

Meredith and Mantel (1995) commented on the extensive growth of project management that "the use of projects and project management continues to grow in our society...The past several decades have been marked by rapid growth in the use of project management as a means by which organisations achieve their goals...'. Another study by Walker (1998) studied the impact of client representative and their influence on the project's performance. He suggested that there it is recommended to have a client representative mainly for building a relationship between stakeholders which has the greatest impact on project success. Walker (1998) has produced a recommendation for clients enables them to choose the suitable client representative who would be ‘good' in project time-saving. The suitable client representative should have: in-depth knowledge of the project's nature in terms of scope and complexity, the ability to provide and accept advice for design and construction, ability to clearly communicate client's objectives, have good team-building and interpersonal skills, and to have good communication skills to achieve all above (Walker, 1998).

According to Kwakye (1997), there are many advantages to using a project management consultant. These advantages include: having the brief prepared by a skilled professional; having a professional manage any confrontations; releasing the architect from management; an independent and sole point of contact for the client. Most of these advantages and disadvantages have been reported by many other researchers in various forms (Masterman, 1992; Lam & Chan, 1994; Murdoch & Hughes, 1996; Hughes, 1997; Love *et al.*, 1998; Ma & Chan, 1998).

Although most of over mentioned advantages are consider from client perspective; there is a major advantage for the benefit of the architects which is releasing them from the management according to Kwakye (1997) and Spinner (1998); which could be argued as management is not their best skill. Arguments have also been raised about evaluating the performance of PMC and how positively or negatively they influence on the project. According to Kometa, Olomolaiye and Harris (1996), previous studies have validated that an efficient consulting procedure interlinking clients with consultants closely which consequently enhance the value chain of construction projects. This concludes that value engineering is a useful tool to appraise the performance of PMC for the clients.

There are two approaches to measure the quality extent of consultants' services. One is using a number of firm factors, for example, past performance, the background of firms, and the capability to achieve the work and project objectives (Cheung, Kuen, & Skitmore, 2002). The other approach is to use some project-related factors, such as clarity and comprehensiveness of drawings and documents, design submission number, and recommendations to minimise project risks (Chow& Ng, 2009).

In relation to the second approach for measuring the quality of consultant's services, Ceptureanu et al. (2007) also suggest that consultancy in a construction project should perform a key role in the achievement of key success factors of project management. In this case, PMC should be considered to be successful if it: (a) facilitates the completion of project in time (i.e.

time criterion); (b) ensures that the cost does not exceed the planned budget (budgetary criterion); (c) ensure that all goals are achieved as initially set (efficacy criterion); and (d) ensure that all stakeholders that are likely to be affected by the project are satisfied (Ceptureanu et al., 2007).

2.5.5 Challenges in the execution of PMC role

It is also important for the current study to facilitate an understanding of the key factors that could affect the ability of PMC to achieve success in construction and infrastructure projects. Among the main factors include the level of project complexity, the nature of contractual arrangements and the competency levels of the consultants. Literature also indicates that PMC success could be affected by how well PMC is able to balance the various objectives (Faulconbridge, 2011). For instance, the consultants need to balance multiple and competing objectives in relation to time, quality and cost. Where compromises are required it is up to the PMC to ensure that agreements are made with all relevant stakeholders such as client and project manager (Jha, 2011).

In the study by Alexandrova and Ivanova (2012) it was also emphasized that the extent that PMC is effective in delivering its role could be affected by a range of internal and external factors such as support from top management, clarity of project objectives, the level of accuracy on project information, the ability to achieve effective communication with all project stakeholders, the extent of access to organizational resources and quality of subcontractors. However, there is a dearth of studies that have sought to establish further the extent to which these aspects pose problems to individuals involved in PMC.

From yet another perspective, it can be noted that PMC often has to interact with a range of other stakeholders such as architects, construction manager and engineers. While it is anticipated that such interactions should be amicable and based on well-stipulated guidelines, the literature suggests that it is common for disagreements to arise thus giving rise to uncertainty. The conflicts are likely to emerge since consultants as part of their work may interrupt and question everyday processes and practices with the aim of aligning them to ensure that project objectives can be effectively achieved (Muzio et al., 2011). It is for this reason that Clegg et al. (2004) conceptualises consultants as "parasites" who create "noise" by disrupting the existing order and enabling the creation of a new order. This view that considers PMC as a privileged arena has, however, is criticised on the basis that consultants often have domain knowledge and expertise that is required (Sturdy et al., 2004). They are therefore instrumental in introducing transitions that have a positive impact on the achievement of project success.

The study by McGivern et al. (2017) also makes use of the temporal politics and temporal works perspectives to explain the cause of conflicts between management consultants and other professionals involved in the actual execution of the project. According to these authors management consultancy commonly entails measurement of activities and imposition of quantitative time deadlines with the aim of increasing efficiency and control in an organisation or project. Conversely, professionals such as architects and engineers often conceive their work in uncertain, indeterminate and open-ended terms. It is the process of aligning the divergent temporal orientations that sometimes generates conflicts between the consultants and the project professionals. While on the same context, Bakker et al. (2013) and Reinecke and Ansari (2015) argue that it is common for actors to resist the imposition of short time frames that construct phenomena in a simplistic way. The suggestion, therefore, is that PMC while engaging in their role may overlook the complex, broader and longer-term factors that are involved in project delivery.

In a study of a large Swedish construction company, it was, for example, found that the project practitioners often discredited the consultants citing that they lacked knowledge of construction. The impact was that the consultants lost legitimacy and were unable to implement their novel ideas due to power struggles (Räisänen & Löwstedt, 2014). This suggests that consultant's delivery of their role may be negatively affected by differences in fields of expertise with other project stakeholders. There is yet to be substantive research on the extent to which such problems are pervasive across the construction industry and how PMC have sought to overcome the hurdles.

2.6 Chapter conclusion

In conclusion, the construction methods and the constructed structures have come a long way since the early ages when construction first began. Today, there are elaborate, creative and highly functional structures that range in size and complexity. Through all of this development, however, there is a widespread inefficiency in the project delivery with most of the construction projects overrunning their time and budget. Upon investigation, it was found that there is a lack of client satisfaction and delivery team satisfaction, the construction industry is suffering from a bad reputation, it has low profitability and a lack of development and innovation. There is also a general lack of trust and confidence between the key stakeholders of the construction industry. Issues of interoperability, lacking technological upgrades, lack of appropriate resource management, and several other performance issues lead the impetus for requiring lean construction management. Applying lean construction management has been found to reduce wastage of resources thereby lowering the cost and driving up the profitability as well as enhancing the interoperability of the construction projects. In addition, integrated project delivery (IPD) can lead to better performance, better alignment of stakeholder interests and project objectives. An early application of BIM leads to increased efficiency in project management.

Just as the construction requirements and outputs have undergone an evolution, the role of the Project Management Consultant (PMC) has also undergone an evolution. Over time, there were more and more people brought on board to manage the construction projects. For a long time, the master builder has been the individual to carry out many tasks. However, once the projects started becoming increasingly complex and large scale, the role of a construction manager was created to serve as a coordinator between various moving parts of the project. Several definitions exist of the PMC's functions and roles in the academic literature and practical world. However, a lack of coherence in these definitions is evident with new research adding more functionalities to the PMCs role. Regardless of the lack of coherence in what the PMC is supposed to do, there appear to be several benefits of hiring a PMC to manage the complex projects. In general, a PMC ensures maximizing client satisfaction, optimal use of resources, time and budget management, and maintains the efficacy of the project. A PMC also faces several challenges such as disputes between stakeholders, lack of trust and credibility, power struggles, conflicts between designers and engineers, lack of clarity of project deliverables, and the resulting complexity of the PMC's job. A lack of research was identified in the area of how the challenges faced by the PMC are tackled.

Chapter 3

Building Information Modelling

3.1 Introduction

The literature review undertaken in this research comprises of two main parts. The first part focuses on a review of existing studies on building information modelling (BIM) in terms of definition, development and implementation, an overview of development through the recent years and the benefits for construction projects and the construction industry in general. The second part explores existing limitations in the construction industry such as the lack of performance in comparison to other industries. It also reviews the importance of adopting innovative technologies as a way of enhancing practice within construction projects and the industry in general.

3.2 What is BIM?

The construction industry is one of the biggest consumers of extracted materials. For example, Pedersen (2012) point out that in the U.S. over 2.5 billion metric tons of materials are used in the built environment. From these materials, 143.3 metric ton is waste generated from the construction process. In light of such inefficiency, there have been concerted efforts to ensure the sustainable design of construction projects. BIM has in this context been proposed as a potentially effective way of ensuring high performance in the construction industry by transforming the way building designs are created and communicated (Shrivastava & Chini, 2012). BIM constitutes a new multidisciplinary approach to building design and construction. Furthermore, according to Kassem, Succar, Dawood (2015), BIM protocols, BIM guidelines, and BIM standard are three terms that are used interchangeably. This use of the unqualified terms creates a discrepancy in taxonomical knowledge in the construction industry across the globe. It can be posited that this leads to a further

The National Institute of Building Science (NIBS) defines BIM as ‘a digital representation of physical and functional characteristics of a facility, serving as a share knowledge source of information' (Succar, 2009). Volk et al. (2014) also define BIM as an approach to generating and managing building data throughout the project's lifecycle. It provides information concerning project design scope, cost and schedule for all project members during the construction and occupancy phases. In this research Estman's et al. (2011) definition of BIM as `modelling technology and associated set of processes to produce, communicate and analyse building models is adopted.

BIM is essentially an advancement of the computer-aided design (CAD) that has been traditionally used in the Architect, Engineering and Construction (AEC) industry (Shrivastava & Chini, 2012). Notably, CAD was introduced as early as in the 1960's and has since then been changing following advancements in technology and innovations related to the computing and software technology. At present CAD can support 4D (3D + time) and 5D (3D + plus time and cost) designs (Azhar & Brown, 2009). However, limitations associated with the incorporation of information in CAD models have made it less effective in supporting superior design decisions (Arensman & Ozbek, 2012). BIM as a newer approach solves this problem by allowing users to superimpose multi-disciplinary information within one model. In other words, BIM can incorporate non-graphical object data into the model. As a result, diverse measures of performance and sustainability can be achieved through the design process.

3.3 History of BIM

The tradition in AEC industry until the early 1990's involved relying on a process driven by 2D paper design for building design documentation process. The main limitation of this approach was the barrier it created towards creatively and collaboration in design (Taylor & Bernstein, 2009). The used of paper-based communication further proved to be problematic in terms of creating additions, claims and assessing omissions and delays in design (Eastman et al., 2011). Over time various initiatives to solve these problems such as the use of the web for real-time communication as well as the implementation of 3D CAD tool for better visualisation have been implemented. However, these initiatives and methods proved to be problematic in terms of time consumed during information exchange. In addition, the electronic versions did not have a significant impact on intensity and conflicts caused by paper documents (Bryde et al., 2013; Khosrowshahi & Arayici, 2012).

The realisation of the above barriers and limitations has been instrumental in the development and popularisation of BIM. More specifically, advancements in BIM have focused on utilisation of technologies to improve the flow of information, reduce errors in design and increase efficiency in the construction process (Demian & Walters, 2014). The demand for such technologies has further been exacerbated by increasing complexity of construction processes. Larger projects have been characterised by increased difficulties in managing information and the multiple stakeholders such as owners, designers and contractors (Ghaffarianhoseini et al., 2016). As illustrated in figure 1 a large-scale project in the current times could have a large number of stakeholders. If project managers were to rely on 2D communication valuable time and expenses could be consumed. Furthermore, structural analysis done on design could be provided when it is already too late to improve design (Eastman, 2011). BIM overcomes this challenge of efficient communication through harmonised communication and data exchange that keeps in the front line of the process enhancement.

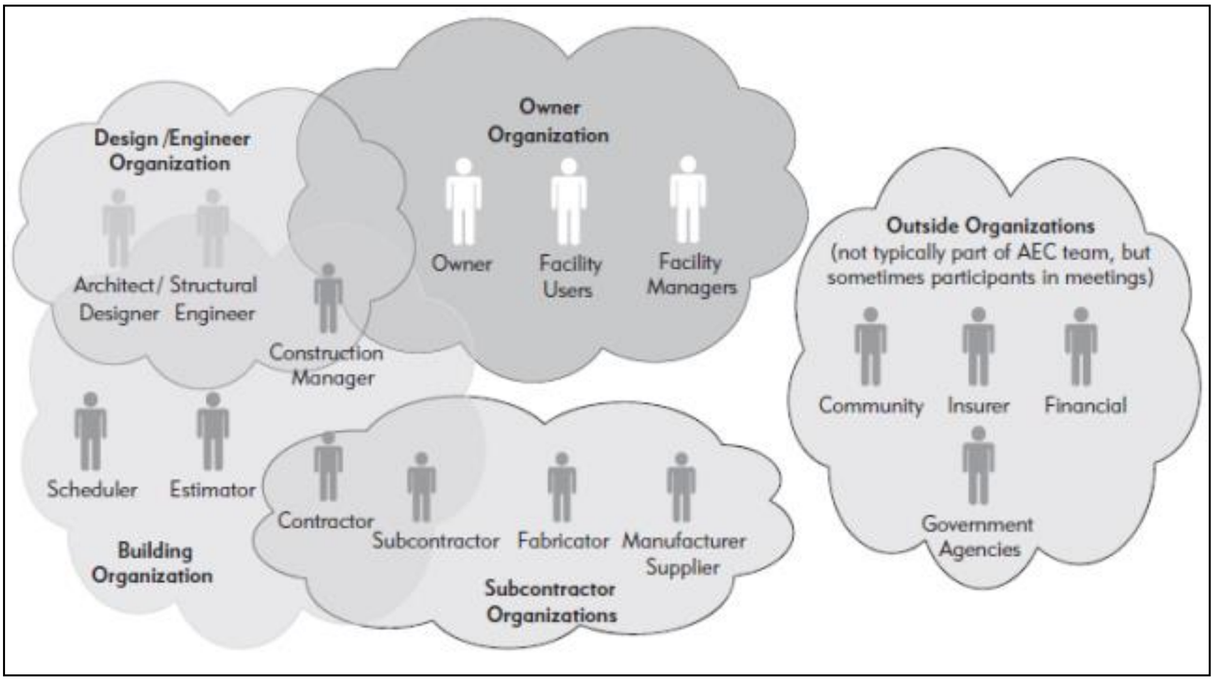


Figure 3.1: Conceptual diagram representing an AEC project team and the typical organisational boundaries (source: Eastman, 2011)

3.4 Recent research on the development of BIM

With regard to the continued development of BIM, the recent times have been marked by advanced research in several dimensions. One of the dimensions relates to information related aspects of BIM. In order to ensure data-level interoperability in BIM standardisation is being pursued. In the UK and US nationwide standards for BIM are being developed with the aim of formalising information exchanges and processes and workflows in the model (Eadie et al., 2015). The aim is to ensure that BIM evolves to a project management method as opposed to a model for only managing building design information (Isikdag, 2015).

The second dimension relates to organisational aspects such as adoption and maturity. In relation to adoption, it has been shown that a significant number of organisations find it difficult to move from CAD-based thinking to utilisation of BIM (Jung & Joo, 2011). Such difficulty has been associated with the need for transformation of formal management process such as in the case of the transition from traditional accounting packages to use of enterprise resource planning (ERP). Industry experts are however recommending a phased approach to the adoption of BIM (Aranda-Mena et al., 2009). With regard to maturity, the research underscores that success in implementing BIM is dependent on organisational readiness in which case organisations must adopt technologies and methodologies that complement BIM (Succar, 2009).

A third dimension pertains to domain-specific aspects such as Green BIM. Environmental protection has become a globally sensitive issue (Bynum et al., 2012). In the construction industry, there is increasing pressure to build more environmentally friendly buildings that have a lower carbon footprint. BIM has been proposed as a strong tool in this area due to its ability to support green design that emphasises on lean construction (Azhar et al., 2011). The final dimension pertains to project management aspects. In this case, process simulation and monitoring have been identified as key parameters of the effective building. BIM has been shown to be more effective compared to CAD in a visual simulation of the building process. In addition, there is increased research pertaining to how BIM can facilitate more effective clash detection (Diang et al., 2014).

3.5 BIM benefits for the AEC industry

BIM has been documented to have a range of benefits in the AEC industry. One of the benefits is in relation to the ease of updating. A prior study by Tse et al. (2006) indicated that in Hong Kong one of the most cited reasons for usage of BIM was its ability to allow for updating of all other related views by making a change in one view of the model. While still in the context of Hong Kong, Wong et al. (2009) reported that specialist consultants found it increasingly efficient to transfer traditional paper drawings to the 3-dimensional (3D) model using BIM. The resultant impact was enhanced coordination between the various building services such as drainage, fire services, plumbing and HVAC. Furthermore, BIM significantly speeded up the quantity take-off process as well as drawing documentation (Wong et al., 2009). Similarly, the literature indicates that BIM also offers simulation benefits to users in the AEC industry. It can not only simulate 3D, 4D and 5D building models but also a range of other operations that cannot be operated in the real world. Examples of such operations include simulating sunlight, emergency evacuation and heat transfer (Nawari, 2012, Mayo, 2012). BIM further provides a platform through which integrated management in aspects such as feasibility studies, objective design and planning and supply can be undertaken in an efficient way (Succar et al., 2012). Kassem, Iqbal, Kelly, Lockley, and Dawood (2014) developed BIM collaborative design which when applied at the project level can increase the efficiency of the entire supply chain as well as streamline the BIM deliverables and flow.

In relation to sustainability as the current interest in the construction industry, BIM has been shown to offer various benefits. Wong and Zhou (2015) for instance indicate that BIM allows for a reduction of material needs and provides opportunities for the use of recycled materials. In addition, conducting of daylight analysis is significantly enhanced. As such, BIM supports the development of lean approaches to the management of construction projects. From another perspective, Azhar and Brown (2009) found that BIM contributes to sustainable design by facilitating analysis of building form and optimisation of the building envelope as well as a selection of the best design that allows for minimum energy costs. Other contributions of BIM towards sustainable or green designs include reduction of both water and energy needs (Schuleter & Thesseling, 2009; Shrivastava & Chini, 2012). These green benefits are achieved through BIM through the use of virtual prototyping/visualisation technology in predicting, managing and monitoring the environmental impacts of various designs.

BIM also has the potential for being a catalyst for increased ease at which project managers and consultants are able to re-engineer their processes to better integrate different stakeholders (Bryde et al., 2013). The ability to engage in re-engineering is linked to utilisation of the seven pillars that constitute the BIM implementation strategy. They include waste elimination, increased feedback, delay of decisions in order to achieve consensus, fast delivery, build-in integrity and empowerment of the team (Arayici et al., 2011). For existing buildings, BIM BIM offers several diversity management benefits. These include tracking of warranty and service information, emergency management, retrofit planning and monitoring and assessment among others (Ghaffarianhoseini et al., 2016). The integrated approach in BIM further offers benefits such as increased complexity of construction projects at greater levels of efficiency. Integration also improves the procurement process through increased accuracy of quantities for building materials and components related to a certain design (Chien et al., 2014; Bryde et al., 2014).

Greater efficiency in overcoming the project management triple constraint associated with time, cost and budget have also been cited as one of the reasons why BIM has become increasingly popular in the AEC industry. Specifically, it is estimated that use of BIM in construction projects can lower costs by 33%; increase the speed of delivery by 50%; contribute to sustainability by lowering greenhouse gas emissions by 50%, and improve exports of construction products by 50%. A survey by McGraw-Hill Construction also identified benefits that key stakeholders in the AEC derive from the use of BIM (see figure 3.2). These benefits include a reduction in conflicts and changes during construction, improvement in overall project quality, reduced risk and better predictability of outcomes, better performance of completed infrastructure and an improvement in the review and approval of construction cycles (Autodesk, 2013).

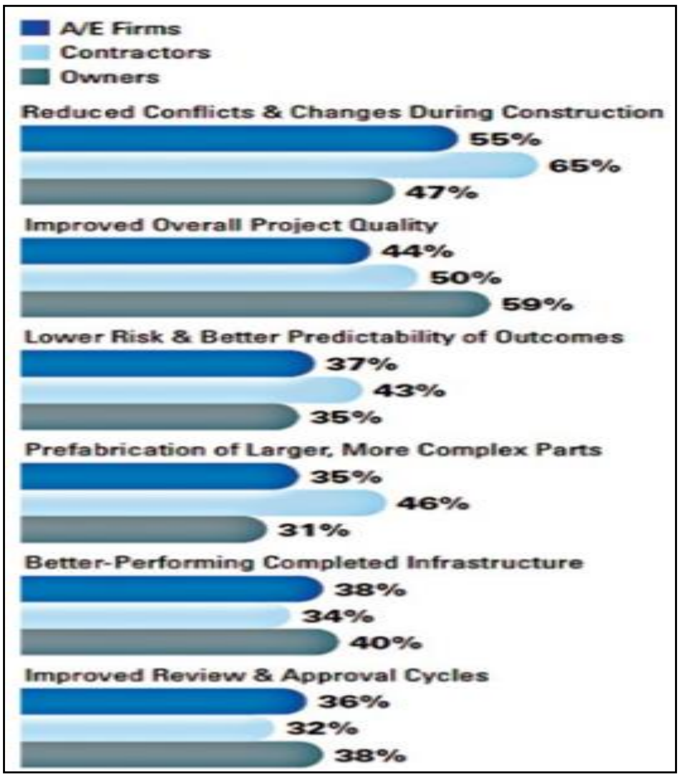


Figure 3.2: Benefits of BIM to stakeholders (Autodesk, 2013)

3.5.1 Challenges in BIM adoption and execution

Despite the benefits associated with BIM, adoption rates, especially in developing countries, are yet to reach high levels. In developed countries such as the UK and the USA, the adoption rate by both the government and private sector has been high. A National BIM Report for 2016 in the UK by the National Building Specifications (NBS) for instance revealed that more than half of the professionals (54%) in the AEC industry were using BIM on at least some of their projects while another 42% were aware of it (Nawari, 2012). In developing countries such as Malaysia and the United Arabs Emirate (UAE), BIM has been well received, but the adoption rate has been relatively slow (Eadie et al., 2013; NBS, 2016).

According to McKensey Global Institute study published in 2016; the construction industry is among the least industries adoption for digital solutions.

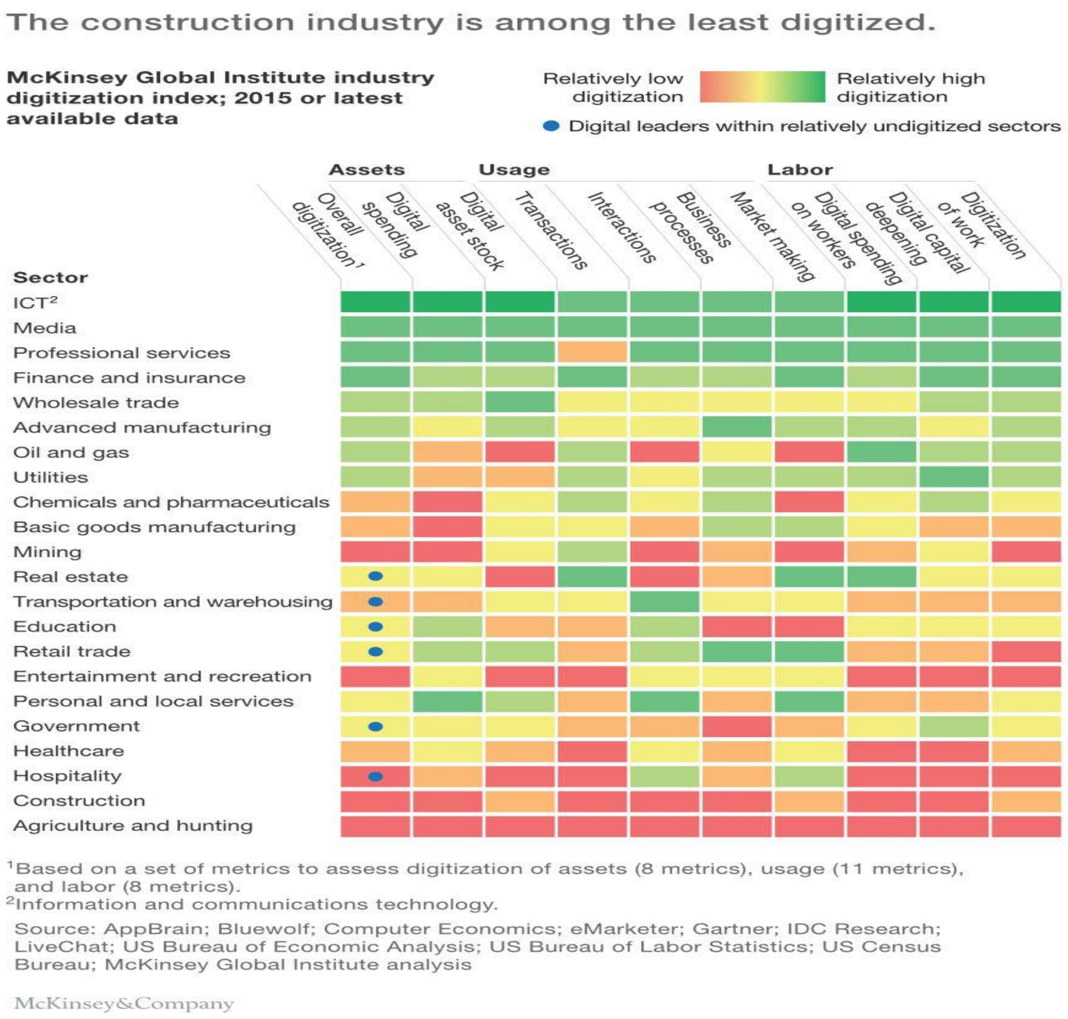


Figure 3.3: Industry digitalization index (McKensey Global Institute, 2016)

One of the key barriers pertains to the relatively steep learning curve that is associated with the switch to BIM technologies. According to Demian and Walters (2014), the first batch of employees to undergo BIM training in a company is likely to be unproductive. The low productivity is associated with the need for employees to learn how to customise the BIM tools to the needs of the company. Interoperability is also a key problem. Grilo and Jardim-Goncalves (2010) in the study of the US construction industry found that inadequate interoperability leads to costs of over $15.8 billion annually. BIM requires the development of new standards in order to facilitate interoperability, but stakeholders have been slow in establishing such standards. Similarly, Cerovsek (2011) indicates one of the issues affecting the adoption of BIM at the global level pertains to the standardisation of the BIM standards. In order to facilitate the collaboration between the stakeholders inside and outside of the BIM environment, it is important that standards for information exchange be agreed.

In the absence of standardised BIM guidelines, it becomes difficult to agree on the quality of information to be used thus further affecting the use and reuse of the information among the partners (Nawari, 2012). Quality of information in this context describes the extent to which BIM standards can be used to provide reliable information that can be utilised by all relevant stakeholders as a basis for making an important decision in all life stages of the building from conception to handover. Furthermore, lack of standardised BMI guidelines negatively affects the extent to which building products and process are interchangeable. This in turn impacts on the identification of products and processes with optimal parameters that would otherwise reduce variety and the associated high costs (Nawari, 2012).

3.6 Current implementations and uses for BIM

The America building SMART alliance has published a BIM project execution planning guide which summaries 25 key uses for BIM in project implementation (Shou et al., 2015). As shown in table 3.1 these uses occur in each of the four key stages of projects: planning, designing, construction and operation. Based on the execution guide the different parties in construction projects should only make use of BIM only in the relevant areas as opposed to usage in all construction aspects. As further indicated in table 3.1 the most important uses of BIM in each phase are classified as primary uses while other uses are considered to be secondary uses.

Phases	Primary uses	Secondary uses
Planning	Existing conditions modelling Cost estimation Phase planning Programming Site analysis	
Designing	Design reviews Design authoring Energy analysis	Structural analysis Lighting analysis Mechanical analysis LEED evaluation Code validation
Construction	3D coordination Site utilisation planning 3d control and planning	Construction system design Digital fabrication
Operation	Maintenance and scheduling Building system analysis	Asset management Space management/tracking Disaster planning

Table 3.1: Primary and Secondary BIM uses in a project lifecycle (source: Haron et al., 2010)

Besides the use of BIM in the building, this process is increasingly being applied in the infrastructure industry which comprises of bridge, airport and road construction (Taylor & Bernstein, 2009). In the design phase of infrastructure projects, BIM can be used for land use and transportation planning, traffic impact simulations and quantity take-off. At the procurement stage, BIM has been shown to be suitable for producing product master data, facilitating automation of procurement and product inventory management (Shou et al., 2015; Ibrahim, 2013). During the actual construction process uses of BIM, include virtual project scheduling, virtual work planning, geospatial issue tracking and equipment management. Lastly, BIM can be used in the operation phase of infrastructure projects for purposes of toll and facility management, Geographic Information System (GIS) asset tracking and emergency response and repair (Shou et al., 2015).

3.7 Current BIM standards

3.7.1 Definition and applications of BIM standards

Standards from a BIM context are methodologies used for the transfer between parties of structured information. Such information is related to facilities (i.e. buildings and infrastructure) and defines the various expectations for each of the phases of the project lifecycle (Jung & Joo, 2011). BIM standards also help in clearly defining the components and processes of creating a BIM model at various stages of a project (Azhar et al., 2011). Several countries utilize the open standards and data specifications of BIM such as IFC and COBie which facilitates the distribution of digital information and data in a streamlined manner (Patacas, Dawood, Vukovic, & Kassem, 2015).

In the UK different BIM standards are targeted for various levels of the BIM maturity ramp (see figure 2). In brief, level 0 BIM is characterised by CAD including 2D drawings that may include the electronic exchange of information but lacks common standards and processes. Level 1 BIM incorporates managed CAD, and unlike level 0 there is higher levels of coordination and use of standardised structures and formats (Paterson et al., 2015). Level 2 BIM, on the other hand, incorporates managed 3D environment. At this maturity level, the attached data is held in separate discipline BIM tools and is managed using business process management systems. Time planning and cost planning are also incorporated at level 2 (Succar et al., 2012).

BIM level 3 constitute the most advanced level which allows for high levels of integration and interoperability of data. It supports sequencing (4D), cost (5D) as well as the provision of project lifecycle information (6D) (Lin et al., 2015). Notably, BIM maturity levels are used by organisations to express their BIM ambition level. For example, most organisations strive to achieve BIM level 2 in the short or mid-term while level 3 is targeted as a long-term goal (Mahdavi & Scherer, 2014). In this section BIM standards used in the UK, US and Singapore are reviewed.

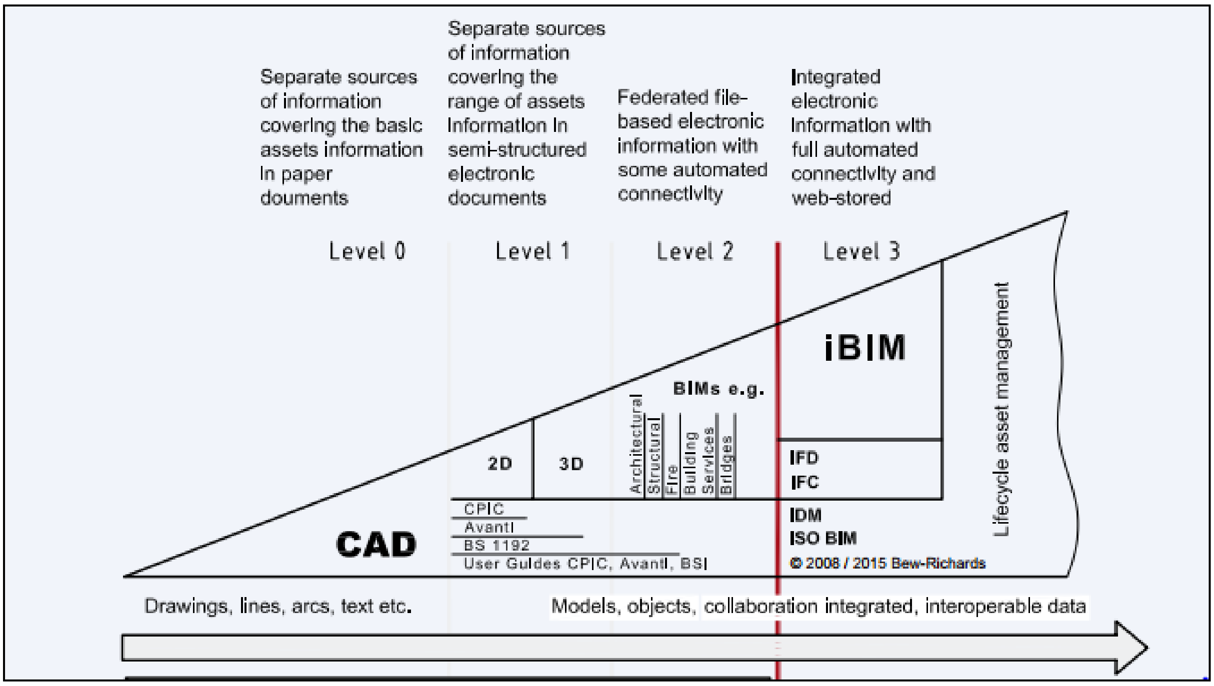


Figure 3.4: BIM maturity levels (BSI, 2014)

3.7.2 European BIM standards

(a) UK BIM Standards

British Standard (BS) 1192-4

BS 1192-4 is a standard that is used to define the usage of COBie (Construction Operations Building information exchange). In brief, COBie is an internationally agreed information exchange schema that facilitates the exchange of facility information between project owner/employer and the supply chain (Anderson et al., 2012). Several characteristics of COBie make it particularly instrumental and effective in the exchange of building information. First, users of COBie can prepare and use information without necessarily having knowledge of the sending and receiving databases. Second, the standard is designed in a way that it ensures high ease of review and validation of information exchanged in relation to compliance, continuity and completeness. Third, COBie can be used with less structured projects (i.e. UK level 1 BIM) (BSI, 2014).

In the UK the government makes use of COBie to exchange information for federated building information management (UK level 2 BIM) for purposes of integrating commercially valuable information with other aspects of its business. As depicted in figure 2, COBie can be used to hold information concerning the facility's spatial locations, equipment and components.

Manageability of each of these aspects is achieved by allocating spatial locations to intermediate addresses while equipment and components are assigned to common specifications as well as grouped by functional purposes (BSI, 2014).

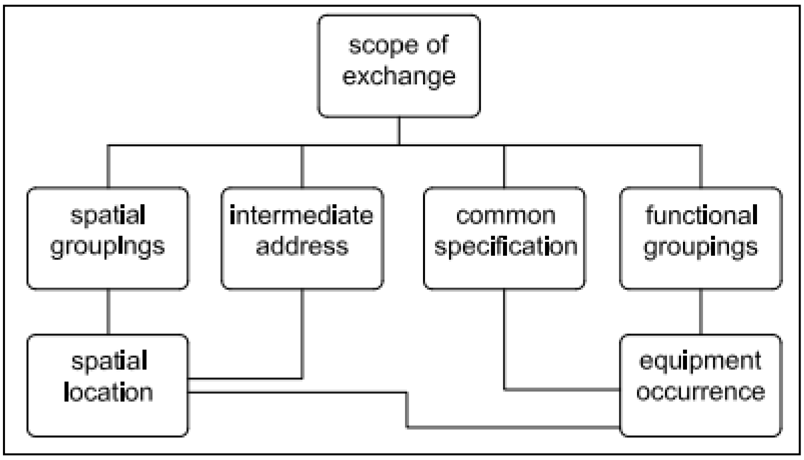


Figure 3.5: Generic view of COBie (BSI, 2014)

PAS 1192-5 – security of information

BIM, in general, seeks to support the seamless exchange of information in a transparent environment. Despite the benefits of such an efficient exchange, there is an underlying risk of loss or disclosure of sensitive information. The impact could range from compromised safety and security to the theft of commercial information and intellectual property (BSI, 2015). Publicly Available Specifications (PAS) 1192-5 seeks to solve this problem concerning the security of information exchanged through BIM. This standard is specifically addressed to asset owners and other stakeholders to help them in understanding key vulnerabilities issues as well as controls that should be put in place to deliver trustworthy and secure digital data within the built environment (Boyes, 2015).

Security threats as underscored in PAS 1192-5 could affect all phases of the project from conception to disposal/demolition (Hafeez et al., 2015). Notably, the standard goes beyond physical security of the built asset to the technological aspect of security. Key facets of technological security include: confidentially, which encompasses control of access of data; integrity, which involves ensuring the consistency and coherence of information and systems; and authenticity, which involves ensuring that inputs to and outputs from built asset systems are genuine and have not been tampered with or modified. Other aspects include safety, resilience and availability of data (BSI, 2015).

PAS 1192-2: 2013- collaboration through electronic information

This PAS revolves around the need to achieve level 2 BIM which focuses on collaboration through electronic information that makes use of some automated connectivity. It constitutes a progression and improvement of BS 1192:2007 which defines requirements for collaborative production of information pertaining to architectural, engineering and construction (BSI, 2013). It should, however, be noted that PAS 1192-2 mainly focuses on the project delivery aspect which requires data to be accumulated from design and construction activities. Given that construction is a collaborative work environment, the PAS underscored the need for standardised processes and agreed on standards and methods of producing information (Neath et al., 2014).

It has, within the above context, is shown that use of standardised information through a single collaborative data environment (CDE) allows for the production of high-quality data that can be used and reused with change or interpretation (BSI, 2013). Standardised data in construction has further been indicated to support lean construction by reducing the number of wasteful activities. These include time spent in waiting and searching for information, overproduction of information, over-processing information and defects associated with poor coordination of information which necessitates reworking (BSI, 2013; Neath et al., 2014).

BS 1192: 2007 – collaborative production of AEC information

BS 1192:2007 constitutes a UK level 1 standard in the BIM maturity model. It entails the collaborative production of architectural, engineering and construction information. The basis of the standard is that the efficiency of delivery of facilities is contingent upon collaboration between the different stakeholders in construction projects (Jayasena & Weddikkara, 2013). Similar views have been expressed in literature in which case it has been shown that the use of non-standard data significantly slows down work processes through misinterpretation and contradictions (Shafiq et al., 2012). As a level 1 standard, BS 1192:2007 is applicable to technology-enabled processes including automated 3D models, data, drawing and documentation; indexing and searching project materials; filtering and sorting; and quality checks.

BS 8536-1: 2015 – briefing for design and construction

BS 8536-1 is also referred to as briefing for design and construction and represents part of the ongoing efforts to achieve standardisation. The standard’s main focus is on aspects of design and construction that are directly related to achieving the required levels of operational performance of new or refurbished assets (BSI, 2015). In addition, it is meant for use in level 2 BIM though it does not preclude other maturity levels. Another notable aspect of BS 8536-1 is that it underscores the importance of adopting a whole-life view of an asset as opposed to solely focusing on design and construction. Accordingly, the design and construction team (i.e. architects, structural & mechanical engineers, real estate managers and facility managers), as well as operators/asset managers, are involved from the outset to the defined periods of aftercare for the asset (Kelly et al., 2016).

PAS 1192-3: 2014 – specification for information management

This PAS is designed for use by individuals charged with the responsibility of operating, maintaining and strategically managing assets (BSI, 2014). Inconsistency with the responsibilities of this target group, the PAS covers data transfer processes that are related to the creation of Asset Information Model (AIM), exchanging of asset information with Project Information Model (PIM), recording information that relates to the disposal of an asset and the use of AIM for purposes of supporting organisational requirements. As a level 2 BIM standard, the PAS supports planned preventive maintenance of assets as well as portfolio management of an asset during its lifetime (Eynon, 2016).

BS_8536_1_2015 - Code of practice for facilities management

The standard offers guidelines and recommendations regarding the information and data that project stakeholders need in order to enhance optimum operability and performance of the facility. As such, the standard is limited to the operational phase of the project lifecycle (BSI, 2015). It can, however, be noted that information offered in this standard is still important in the design and construction phases where issues to operability are taken into consideration.

This standard articulates the roles of various project stakeholders although at the general level as opposed to roles at each phase of the project. The owner is required to determine the composition of the design and construction team and emphasis on collaborative working. The owner's representative (PMC) is on the other required to liaise with the design and construction team to ensure the required project outcomes and operational performance are taken into consideration (BSI, 2015). General roles for the operations team and facility manager are also described.

(b) Norway BIM standards

Currently, Norway BIM standards are published by Statsbygg (government department) and the Norway Association of Construction. The BIM manual offered by Statsbygg mainly focuses on defining the requirement that applies to the BIM deliverables. At the basic level, two sets of requirements are identified: The open BIM deliverable and BIM objectives. In brief, the open BIM deliverable requires that a digital 3D BIM that is based on object-based design and makes use of open BIM standards be the main deliverable.

The BIM objective, on the other hand, specifies that the BIM shall be modelled for the specific BIM objectives that are specified in the project under consideration (Statsbygg, 2013). An additional 13 domain-specific requirements are also issues as part of the BIM standards (See Table 2). Currently, all Statsbygg projects make use of open BIM principles. Attention while using BIM in the country is mainly given to the environmental impact of infrastructure and the lifecycle costs.

SR No.	BMI specifications/ requirements	Description
1	Architectural modelling	This specification recognises that an effective architectural model should contain other domains in areas such as structural elements and electrical and mechanical equipment. Accordingly, it offers guidelines on components (e.g. generic and superstructure) that should be included in order to ensure an interdisciplinary architectural model. No project stakeholder roles are specified.
2	Landscape architectural modelling	In order to ensure ease of visualisation, this specification provides recommendations on landscaping elements. It explains the need for geometry elements of landscaping to be exported to IFC with the help of CAD systems and also recommends the use of open formats such as LandXML and CityGML for landscaping.
3	Interior design modelling	This specification offers generic requirements for inclusion of information on interior design components such as furniture, fixtures and equipment (FF&E) into BIM. It

		emphasises the importance of the project team agreeing upon the information but does not highlight specific roles.
4	Geotechnical engineering modelling	Development of this specification is still ongoing. Nonetheless, the specification highlights to project stakeholders the risk of use of architectural tools that fail to support other geotechnical engineering processes. It thus supports the need for interoperability through the use of a construction site BIM that corresponds with the structural BIM thus making the transfer of information easier.
5	Structural engineering modelling	This specification covers the requirements for load-bearing elements such as concrete and steel structures and non-load-bearing concrete structures. It highlights the role of the structural designer as one that involves the production of both a design and analysis model that focuses on ease of coordination and improved costing.
6	Mechanical engineering modelling	The specification provides details for modelling requirements in relation to mechanical engineering. It thus covers mechanical aspects of the building process such as plumbing, fire protection, heating and energy control. Besides an explanation of the modelling requirements, the specification does not detail out the specific roles of the mechanical engineer and other stakeholders.
7	Electrical and communications engineering modelling	This specification as the name suggests is limited to modelling aspects of electrical and communication aspects of the building process. It offers modelling requirements for the facility's electrical and communication support systems in aspects such as technical space and geometry. Roles and responsibilities of relevant project stakeholders are not defined.
8	Acoustical engineering modelling	In this specification, the modelling requirements for acoustic properties for a range of building elements such as constructions and installations are explained. It also emphasises the importance of communicating acoustics

		conditions to the design team in the BIM. The acoustic engineering is recognised as playing an important role in providing relevant data, but the roles of other stakeholders are overlooked.
9	Fire safety engineering modelling	This specification sets out the fire safety conditions that the safety engineer needs to include in the BIM. The overall goal is to ensure that building projects that utilise BIM have adequate protection to fire and have a layout and space planning that allows for efficient evacuation.
10	Other design and engineering modelling	The specification recognises that the process of modelling entails a wide range of special disciplines that may differ from one from one project to another such as kitchen and laundry in hotels and hospitals. Accordingly, it emphasises the need to include such disciplines as part of the BIM information.
11	BIM construction and as built requirements	BIM in Norway is currently limited with respect to the construction phase. However, this specification indicates that contractors are free to use the BIM as they choose. It also explains a few general roles of the contractors which include receiving and using the finalised generic design-BIM, reporting changes to client and design team and updating the native BIM.
12	BIM for facility management and operations	This standard is also in the development process. It explains the need for transforming the "as built" BIM to the facilities management and operations (FM&O) BIM for the operations phase of the facility.
13	BIM for decommissioning and disposal	Specific requirements for this standard are not stated. However, it mentions that BIM may be used in extracting relevant information at the decommissioning and disposal phase which can be relevant in the handling of reuse and waste fractions.

Table 3.2: BMI specifications in Norway Statsbygg (2013)

(c) Finland BIM standards

Finland constitutes one of the countries in Europe that has a long tradition in the use of BIM. At present four maturity levels have been defined (Elliott & Hamid, 2017). BIM level 1 and 2 are already in progress. At level 1 the main focus is on data management for document-based structures, 2D and 3D documents while level 2 maturity involves visualising information in combined models. Level 3 and 4 are future maturities in which information is expected to support the owner's processes and lifecycle management and also be linked with the built environment.

An evaluation of the standards in Finland indicates that they have been put forward in the form of requirements that must be attained by stakeholders in the AEC industry (Building Smart, 2015). The current standards can be found in the publication series "Common BIM Requirements 2012" which articulates 12 areas that are relevant to procurement and construction (Building Smart, 2013) (see Table 3.3). It can, however, be noted that there are relatively low levels of standardisation of BIM in Finland. A large number of construction firms have been writing their detailed requirements and best and also the majority of large consulting firms have their BIM groups (Building Smart, 2015).

Standards/ specifications	Descriptions
General BIM requirements	This general specification outlines the basic principles, requirements, concepts and targets for BIM in projects. It clarifies that it is the role of the BIM coordinator to apply the targets as well as supervise the use of the model.
Inventory models	This specification describes requirements for building site modelling. It covers inventory models and emphasises the need to use reliable and accurate sources of data that make implementation of plans easier.
Architectural design	This specification explains that the architect BIM is mandatory in all the design phases and specifies the requirements in each of these phases. No specific roles of project stakeholders are included.
HVAC + EA Design	This part focuses on building services (BS) design task. It specifies the contents for the BS system model in terms of basic prerequisites for the

	use and maintenance in the life cycle of the building. Although it provides information content and geometry in each of the phases, it fails to specify the roles of project stakeholders.
Structural engineering	The part breaks down the requirements for structural engineering process into a list of BIM tasks. In order to enhance collaboration, this specification takes into account the needs of other design team parties. This, in turn, makes the requirements easier to adopt.
Quality assessment	The specification focuses mainly on information producers mainly designers. It explains that these information producers should ensure that the contents of information should be appropriate and reliable in order to enhance the viability of BIM. Checklists -
Quantity takeoff	In this part, the essential BIM requirements and guidelines for use in quantity take-off are described. It highlights that the requirements are relevant for owners, designers, contractors and product fabricators. It advocates for a shift from manual drawings to computer-assisted measurements for quantity take-off.
Visualization	In the visualisation part, the documents highlight the importance of using technical illustration in BIM as opposed to the traditional photo-like rendering visualisation. It indicates that the technical illustration is to be used by the design team, client and project manager to facilitate easier comparison between different design alternatives and improve communication. However, the roles of these stakeholders are not included.
HVAC analysis	HVAC analysis provides graphical illustrations of lighting calculation and lighting analysis. In the process, it also highlights the possibilities brought into BS analysis by modelling. Relevant stakeholders and their roles in HVAC analysis are not clearly highlighted.
Energy analysis	In a bid to contribute towards sustainable buildings and infrastructure this standard emphasises the importance of energy efficiency management. The requirements for ensuring energy efficiency in BIM are also provided.
Management of BIM project	This specification recognises the importance of using BIM from the client's point of view. Accordingly, it describes the general project management tasks that should be undertaken in order to meet client demands. Planning, implementation and control measures during the

	project process are also included, but the specific roles of project stakeholders are missing.
Use and maintenance of the building	This part provides a description of the requirements for the use of BIM in the use and maintenance phase of the lifecycle. The requirements are in the form of IFC based data transfer as well as other popular transfer methods such as COBie. The benefits of using BIM in facility services processes are also articulated, but key roles of relevant stakeholders in the use phase are left out.
Construction requirements	BIM requirements for the construction phase are explained in this final part. The requirements are meant to be agreed between the project stakeholders on a project basis. The main roles of the contractor at this stage pertain to the delivery of information on adjustments for the as-built model to the client.

Table 3.3: BMI Specifications in Finland (Adapted from: Building Smart, 2015)

3.7.3 Asian BIM standards

(a) Singapore - BIM standards/Guidelines

In Singapore, the Building and Construction Authority (BCA) has recently published a BIM Guide Version 2.0 which details out the relevant information that should be used by construction and precast companies during modelling. Six main modelling and collaboration procedures are explained as part of the Singaporean standards. They include individual discipline modelling, cross-disciplinary model coordination, data security and saving and quality assurance and control (BCA, 2013) (see Table 3.4). Compared to the detailed UK BIM standards, the standards used in Singapore are mainly in the form of best practice guidelines.

BIM standard	Description
Individual Discipline Modelling	This standard provides information on procedures to be undertaken during the modelling of BIM elements. It also provides guidelines for use in architectural and structural modelling for purposes of regulatory submission. It also emphasises the need for the diving model into separate levels based on project size and phase as well as revising the model at the various project stages.

Cross-disciplinary model coordination	This standard provides guidelines on how the various stakeholders can achieve interoperability. It emphasises the need for sharing models and coordinating them with inter-disciplinary parties. Figure 3 provides an illustration of the collaboration required in the standard at various phases of the project.
Model & Documentation Production	This standard projects that conflicts may occur between 2D drawing contract documents and BIM model. In such a case contract documents take precedence but efforts should be made to reduce discrepancies through the generation of 2D drawings from the BIM model and agreement on BIM exchange formats and documentation.
Data security & saving	The standard focuses on BIM security issues. It urges BIM users to establish a data security protocol for purposes of preventing data corruption, misuse or deliberate damage.
Quality assurance and quality control	The standard recognises the need for a quality assurance plan as a way of maintaining the accuracy of the BIM data. It indicates that an effective quality assurance plan should include modelling guidelines, dataset validation and inference checks.
Workflow of design-build projects	This standard outlines the various aspects that should be taken into consideration when producing a workflow of design-build projects. These include aspects such as establishing a BIM execution plan and incorporation of predefined project requirements.
Workflow of design-bid-build projects	While taking into consideration the traditional design-bid-build delivery model, this standard describes the generation of construction model by the main contractor. It includes activities for pre-tender stage and construction stage.

Table 3.4: Summary of the main Singaporean BIM standards (Adapted from: BCA, 2013)

Unlike other country standards, the Singaporean BIM standards clarify the roles of consultants and contractors. The lead consultant is for instance tasked with the role of facilitating the definition and implementation of BIM execution plan, BIM goals and uses. The contractor is on the other hand required to study tender documents and coordinate with design contractors and sub-contractors among other roles (BCA, 2013). It can, however, be noted that these roles are undertaken at the team level. Organizational level roles and responsibilities are yet to be clarified. In specific, the BIM guidelines identify a list of 28 BIM project objectives that should be completed from the conceptual to facility management stages of a construction project. It then provides an objective and responsibility matrix identifying the project members that should be involved in fulfilling the objective. Although a range of stakeholders such as architects, structural engineers, mechanical engineers, contractors and consultants are identified their specific roles are not clarified (see figure 3.6) (BCA, 2013).

	Employer	Architect	Consulting Engineers	Contractor / Quantity Surveyor
Conceptual Design	Provide requirements related to form, function, cost and schedule	Begin design intent model with massing concepts with site considerations	Provide feedback on initial building performance goals and requirements	Provide feedback on initial building cost, schedule, and constructability *
Schematic Design	Provide design review and to further refine design requirements	Refine Design Model with new input from Employer, Consulting Engineers, and Construction Manager	Provide schematic modelling, analysis and system iterations as Design Model continues to develop	Provide design review and continued feedback on cost, schedule and constructability *
Detailed Design	Design reviews. Final approval of project design and metrics	Continue to refine Design Model. Introduce consultants models and perform model coordination	Create Discipline-specific Design Models and Analyses	Create Construction Model for simulation, coordination, estimates, and schedule *
		Finalize Design model, Tender Documents and Specifications, Regulatory Code Compliance	Finalize Discipline specific Design Models, Tender Documents and Specifications, Code Compliance	Enhance Construction Model and perform final estimate & construction schedule, Manage bid process

Figure 3.6: Extract of the Singapore BIM objective and responsibility matrix (BCA, 2013)

BIM Project Objective	BIM Manager	Project members involved in fulfilling the objective A – model author; U – model users							
		Arc	Str	MEP	QS	Con	RS	FM	Others
Conceptual Design *Building massing studies or other forms of data representation with indicative dimensions, area, volume, location and orientation*									
1. All project members appointed at this stage to agree on needs, objectives, process and outcomes of the project. **Suggested Deliverable** • **BIM Execution Plan agreed and signed by related parties**									
2. Create site BIM models for master plan site study and feasibility analysis. - Site Analysis									

Figure 3.7: BIM project collaboration map (BCA, 2013)

3.7.4 Australian BIM standards

In Australia, the development and use of BIM standards are largely coordinated by NATSPEC. The organisation has compiled a list of both local and international standards that players in the industry should use in the construction process (Kuiper & Holzer, 2013). Table 4 provides a summary of some of the key standards. It can be noted that some of the standards have been referenced to BIM in other countries such as the UK and USA where significant levels of maturity in BIM development have been achieved.

Standard	Description
Australia and New Zealand Revit Standards (ANZRS)	This standard is designed for use by clients in the design and construction stages. It allows them to define the project content and data and hence, enhanced ease of communication with consultants.
AEC (UK) BIM Standard	The standard is designed for use by Autodesk Revit users. It is a generic document that is adapted from the UK BS1192:2007 BIM protocol. It seeks to provide information on techniques and concepts that architectural engineers can use at the design stage while utilising BIM technology. The

	roles of other professionals such as Quantity Surveyors, Contractors and Facility Managers are not specified.
US National CAD standard, ISO 13567 and AS 1100	This standard is adapted from the National CAD standard used in the United States. It provides a layering system for information used in the construction process. The classification of electronic building design data in this standard helps in streamlining and simplifying information and communication among key project stakeholders such as owners, designers and construction teams. Although the standard is applicable from the project development stage to use of facility stage-specific roles for various users are not defined.
VA BIM Guide 'Trade colours for Clash detection.'	This standard provides guidelines for clash detection as one of the BIM applications. The guidelines are meant to identify all clash processes so that they can be resolved before commencing the construction process. Specific responsibilities of the design/construction team and BIM manager are explained. However, PMC role is not specified.
National Guidelines for Digital Modelling	This standard provides basic information for BIM users in relation to digital model creation and development. It also offers guidelines on how to engage in simulation and performance measurement. Although the PMC role is not articulated the standard emphasises that one of the reasons for models is to enhance information sharing between consultants and other stakeholders.
MasterFormat, Coordinated Building Information (CBI), Uniclass Table J	The standards provide guidelines for developing a work results classification system. It recognises that the construction industry requires significant collaborative effort. The standard is therefore geared towards interoperability by ensuring that stakeholders can create, communicate and find relevant building information when needed.

Table 3.5: Summary of the main Australian BIM standards (APCC, 2016)

3.7.5 North American BIM standards

(a) United States' BIM Standards

With regard to the United States, BIM standards/ information exchange standards fall under four main categories: construction operations building information exchange (COBie), design to spatial program validation, design to building energy analysis and design to quantity takeoff for cost estimating. The development of the standards is coordinated by the National BIM Standard-United States (NBIMS-US, 2014).

COBie as aforementioned is an international standard that is used for delivering facility asset information (Redmond et al., 2012). In the US, COBie is used for purposes of organising work operations into tasks that add value to the final project as well as tasks that add no value. From this classification, it becomes easier to improve the speed and quality of value-adding tasks while eliminating work operations with no added value (NBIMS-US, 2014). As such, the general role of COBie is to provide a format for the exchange of required asset information.

Spatial program validation requires the application of BIM technology for purposes of quickly and precisely assessing a proposed design performance in relation to spatial requirements (Lee et al., 2012). In the US, the General Services Administration (GSA) requires the application of this standard in order to eliminate instances of overdesigning of facilitates that arise from the use of unreliable data (Kelleher et al., 2010).

Building energy analysis, on the other hand, revolves around ensuring the effective use of energy throughout the entire building lifecycle (NBIMS-US, 2014). The project team is required to undertake an energy performance analysis that allows for energy-conscious decisions to be made early in the design phase. In addition, the modelling standards suggested in this standard allow contractors to detect and reverse the energy-inefficient defects during the construction phase (Che et al., 2010). The result is that the green characteristics of the building can be isolated and improved prior to completion. Figure 5 demonstrates a BIM approach to evaluating energy performance.

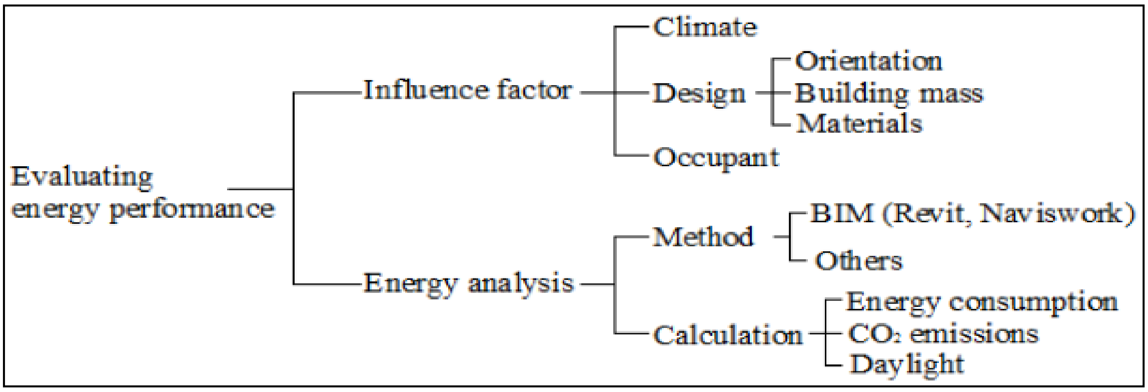


Figure 3.8: Building energy analysis using BIM (Chen et al., 2010)

Lastly, the quantity takeoff for cost estimating provides guidelines pertaining to the use of BIM to assist in making accurate quantity take-offs and cost estimates during the project's lifecycle (Forgues et al., 2012). Application of the standard allows for estimation of the cost effects of additions and modifications to the building. It thus becomes possible to curb excessive budget overruns through better project visualisation as well as precise quantity modelling of materials (Choi et al., 2015).

The study by Lea et al. (2015) indicates that although US BIM standards are comprehensive and are increasingly being adopted around the world, they have several limitations. The authors for example highlight that the standards are highly fragmented in nature, an aspect that can be attributed to the development of the standards in isolation. For example, NBIMS, The American Institute of Architects (AIA) and NIBS have developed their standards separately. Further, some of the BIM presentations such as NIBS have been considered as to length thus making it difficult to read. Alternative standards have been developed by entities such as the University of Southern California, Indiana University and Ohio Department of Administrative Services. Although the standards by these entities are well presented they lack the detail that is evident in NIBS or other equivalent standards such as UK standards (Lea et al., 2015).

(b) Canadian BIM standards

In Canada, BIM guidelines and standards are published by a variety of organisations with the main ones being buildingSMART Canada, Canada BIM Council and Institute for BIM in Canada (IBC). Unlike the UK and USA BIM in Canada is relatively young with key institutions such as IBC being established in 2014. Adoption rates are still relatively low with some provinces such as Canada being marked by 31% adoption rate. Barriers to adoption among non-adopters have been identified and include the lack of demand by clients and the supply chain and high cost of software, training and infrastructure (AEC, 2012).

Further evaluation of the standards indicated that little attention had been accorded to specific roles that project stakeholders should perform at the different stages of the project lifecycle. Only roles and responsibilities related to the BIM execution have been taken into account (see figure 3.6). The main areas of focus have been guidelines on the benefits of BIM for owners, project execution plan toolkits, contract language, practice manual for BIM, collaborative BIM working, interoperability and data segregation (AEC, 2012; IBC, 2016).

	Strategic						Management				Production	
Role	Corporate Objectives	Research	Process + Workflow	Standards	Implementation	Training	Execution Plan	Model Audit	Model Co-ordination	Content Creation	Modelling	Drawings Production
BIM Manager	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N
Coordinator	N	N	N	N	N	Y	Y	Y	Y	Y	Y	N
Modeller	N	N	N	N	N	N	N	N	N	Y	Y	Y

Figure 3.9: Roles and responsibilities for BIM execution (source: AEC, 2012)

Attempts to achieve interoperability at the international level are also evident in Canada. For example, BIM standards and protocols used in Canada were adapted from protocols used by AEC UK. The rationale behind adopted of the framework used in the UK is that BIM enabled technologies are consistently being used in the same way around the world and that it was prudent to make use of already existing standards as opposed to investing time to reinvent and create unique standards for Canada. Adapting of the BIM standards in Canada is also done with reference to US BIM standards published by NBIMS US V2 (AEC, 2012).

3.8 BIM integration to RIBA plan of work

The Royal Institute of British Architects (RIBA) proposes five main stages that project teams should follow in construction activities. They include preparation, design, pre-construction, construction and use (Yusof et al., 2016). BIM while in this context is designed to offer a phase-less workflow thus making it problematic for use with the RIBA plan of work. This constitutes a key issue since governance models used for construction projects must allow for the building to be modelled across its entire life-cycle from concept design through construction to decommission (Rezgui et al., 2013). This integration problem can in part be solved by adding a BIM overlay to the RIBA plan of work.

The BIM overlay process involves identifying deliverables from the BIM process that that project team can use to add value to each of the main stages of the project lifecycle (Azhar, 2011). Integrating the RIBA plan of work with the BIM overlay makes it possible to effectively identify requisite inputs and outputs as well as tools that can enable efficient processes. In addition, the integration process provides a clearer understanding of software applications that can be used for each RIBA workflow process in order to achieve the desired output (Rogers et al., 2015). In this section, a review of the proposed overlay that integrates BIM with the RIBA plan of work is provided.

Preparation (Stage A: Appraisal and Stage B: Design Brief)

Based on the RIBA plan of work, the appraisal stage in the preparation phase should entail the identification of client’s needs and objectives as well as lifecycle and facilities management (El-Sheikh & Pryke, 2010). BIM can be integrated into this stage by advising the client pertaining to the benefits of BIM such as incorporation of 4D (time), 5D (cost) and 6D (facilities management). In relation to the design brief, RIBA incorporates aspects such as the development of the initial statement of requirements into the design, confirming key requirements and constraints as well as the definition of responsibilities (Lou & Alshawi, 2010; Sinclair, 2012). BIM, when integrated into this stage, facilitates the definition of long-term responsibilities as well as the definition of inputs and outputs. Integration of BIM at stage A-B depends on whether it can allow for rapid models that can facilitate analysis of multiple design concepts necessary in establishing feasibility as part of the design brief (Rogers et al., 2015).

Design (Stage C: Concept, Stage D: Design Development and Stage E: Technical Design)

At the design phase (RIBA stage C-E) the concept stage entails implementation of the design brief as well as agreeing on project quality plan and change control protocols. BIM can be integrated into this stage by holding a BIM pre-start meeting through which the initial model is shared with the design team for appraisal. BIM can also be applied to create a model for all major elements (Sinclair, 2012). Design development can, on the other hand, be improved by BIM by providing a data sharing platform as well as an opportunity to coordinate the design process among the team members. BIM is also relevant in technical design (i.e. stage E) since it can be applied in coordinating design, technical analysis and addition of specification data. To contribute adequately at this phase, the BIM model should be such that it can sufficiently outline specification data use in fixing the project brief and obtaining permission for planning (Rogers et al., 2015).

Pre-construction (Stage F: Production Information; Stage G: Tender Documentation; Stage H: Tender action)

At the production information stage, the RIBA plan of work indicates that it should be possible to provide data in sufficient detail to allow for commencement of the tendering process. Such data is obtained from contractors and other project specialists (Sinclair, 2012). BIM can be integrated into this process to facilitate the exporting of data for building control analysis. Tender documentation and action are also improved by BIM through the provision of access to the BIM model by both contractors and sub-contractors. To achieve adequate integration with the BIM plan of work the BIM model should be refined into a virtual prototype that includes cost and programme information that facilitates real-time value engineering (Tuohy & Murphy, 2015).

Construction (Stage J: Mobilisation; Stage K: Construction to Practical Completion)

For the construction phase mobilisation requires letting of the building contract as well as the appointment of contractors. BIM can be incorporated at this stage to help agree on time as well as the scope of soft landings (i.e. scope of post-occupancy evaluation) (Ganah & John, 2014). With regard to construction of practical complementation, BIM plays an important role in coordinating and realising the end of construction BIM record model data as well as cost and time data through 4D/5D BIM data. BIM deliverables required to achieve such integration include revision of the BIM in a way that alternative programmes can be run to simulate and analyse the impact of changes to the construction process (Rogers et al., 2015).

Use (Stage L: Post Practical Completion)

As part of the final usage stage, RIBA requires the administration of the building contract, making final inspections and providing assistance to the user during the initial occupation period (Kassem, 2014). BIM improves this process by providing FM data that corresponds to asset changes that are made. BIM support at this stage is dependent on whether the model has sufficiently being completed and thus acts as an accurate source of data to facilitate management and operation of the building (Ganah & John, 2014).

3.9 Roles and responsibilities related to BIM for each party at each stage

BIM represents a significant shift from traditional management of information in construction (Zanni et al., 2014). The presence of such a shift means that the roles and responsibilities of the different construction players may change. In this respect, this section reviews the roles and responsibilities related to BIM for each of the relevant parties at each stage of the building process.

3.9.1 Planning/preparation

Client – the client/organisation responsible for the costs and benefits of the completed project plays an important role in defining the process of using BIM at the initial of the project. During the planning phase, the client should provide construction details/deliverables to be used in developing BIM requirements (Latiffi et al., 2015).

Architect – as the principal designer the role of the architect in BIM is to help in developing a conceptual design at the preparation stage. The design should then be shared with other parties as part of the briefing process. Notably, the conceptual design comprises of project aspects such as functions, construction methods and materials (Arayici et al., Latiffi et al., 2015).

Subcontractors/contractors – they should provide proposals regarding the appropriate equipment and systems to be used in the project. Such proposals are necessary for developing an early BIM prototype for further refinement (Azhar et al., 2015).

3.9.2 Designing

Client – at the design stage, the client is required to specify information for use in designing through BIM. The information should be concise, unambiguous and accessible (Latiffi et al., 2015).

Architect – at this stage the architect is required to provide a detailed design using BIM. In addition, it is the role of the architect to offer BIM design analysis in preparation for the actual construction process.

Engineers (civil & structural, electrical, mechanical and plumbing) - as part of the professional design team it is the role of the design team to develop design analysis coordination through the use of tools such as Revit Structural and Revit MEP (Latiffi et al., 2015).

Project management consultants – should make use of BIM tools such as Naviswork to identify possible design issues prior to the commencement of the construction process. Through the use of digital BIM model, the consultants should also simulate the process with the aim of identifying construction outcomes that might impact on key project areas which include cost, schedule and quality (Gu & London, 2010; Latiffi et al., 2015).

3.9.3 Construction

Quantity surveyors – as part of the pre-construction process the quantity surveyors should make use of BIM to engage in BIM-based quantity taking off. The outcome is the ability to eliminate quantity taking off errors that are common in conventional methods (Monteiro & Martins, 2013).

Subcontractors – are responsible for providing data on the cost, specifications and schedule of materials being supplied for the construction process (Azhar et al., 2015; Latiffi et al., 2015).

Construction team – should document information pertaining to the facility in both physical and spatial aspects. Physically, the team should documents components and materials being used based on type and group the same into functional systems. Spatially, it is the responsibility of the project team to document spaces and their locations and group them into zones (BSI, 2014).

Lead designer (architect) and contractor – the team of project designers and contractors are responsible for mapping the data to COBie automatically. As part of this role, the contractors are required to specify the required COBie information from their supply chain (BSI, 2014).

Engineers – Engineers have the responsibility of using BIM tools to provide alternate design options as well as coordinate changes whenever modifications are required during the construction process (Latiffi et al., 2015).

3.9.4 Use/Operation

Operations team and facility manager – they have the responsibility of ensuring that usage of the building is duly recorded with the BIM model and available to the other project team. The facility managers can also use BIM for the purpose of leveraging data necessary in ensuring a safe and efficient work environment (Lavy & Jawadekar, 2014).

Subcontractors/contractors – they should supply specialist data pertaining to the use, storage and disposal of materials used in the construction process. After the handover process, the sub-contractors also have the responsibility of monitoring the performance of building systems for purposes of updating the BIM model (Azhar et al., 2015).

Consultants – are charged with sharing security-related information and embedding security-minded behaviour through BIM with other parties such as the operations team and facility manager (Latiffi et al., 2015).

3.10 Chapter conclusion

The review of literature in this chapter indicates that BIM has significantly improved the way stakeholders in the AEC industry share and utilise building-related information. It marks a significant improvement from the use of 2D CAD which is limited in several aspects such visualisation of building data and time used for sharing and utilising data from different formats. In order to enhance the usage of BIM, the literature indicates that different countries are coming up with standards meant to facilitate interoperability in terms of access, sharing and implementation of BIM data using a common set of exchange formats and protocols. The presence of different standards for different countries such as the UK, US and Singapore, however, means that interoperability at the global level remains problematic. Project management consultants also represent an important group of stakeholders in the modelling process and general construction industry. However, studies indicating how BIM can be integrated into the role of this stakeholder group are largely lacking.

Standard	Features
European Standards	• UK Standards focus on the development of a collaborative environment, management of technological and physical assets, production of information, efficient delivery of facilities, improvement of operational performance, data transfer processes (AIM), and recommendations for enhancing interoperability. • Norway Standards provide information on the interior design elements, landscaping elements, develops and interdisciplinary architectural model, enhances interoperability, provided modelling requirements for electrical and acoustic systems, among others. • Finland Standards outline the comprehensive requirements of a BIM project, explains the essential need for BIM in design phases and BS design task, provides information on the structural engineering process, outlines the crucial BIM requirements for quantity take-offs, energy efficiency management, describes the general management tasks, and the use of BIM in the maintenance of the lifecycle.
Asian Standards	• Singaporean standards outline the procedures to enhance interoperability, reduce the discrepancies between the drawings and the documents, encourage the establishment of data security protocols, and allow the development of a quality assurance plan.
Australian Standards	• Australian Standards are employed in the design and construction phases; they deliver information on techniques and concepts, allow for a layering system for information, define specific responsibilities of the design and construction team, and promote collaboration.

North American Standards	• American Standards are divided into four categories: COBie, design to spatial program validation, design to building energy analysis and design to quantity takeoff for cost estimating. They focus on improving the speed and quality of value-added functions while being highly fragmented in nature. • Canadians Standards are in the early stages and are attempting to increase the interoperability.

Table 3.6 Summery of Global BIM standards contents

Chapter 4

Research Methodology

4.1 Introduction

This chapter is designed to provide a systematic overview of the research methodology utilised to achieve the research aims. Using evidence from literature the chapter first identifies what research means and what the research philosophy that is ideal for the context of the construction industry. Following this discussion, the various research methods are discussed briefly providing a critical review of each method. The chapter then goes onto illustrating the various research approaches, reasoning, and strategies. After sufficient analysis, the selected methodology has been introduced with evidence into the benefits and limitations of the same in the context of this research and the construction industry. The chapter concludes with a brief on the measures established to ensure that an ethical, unbiased, and high-quality research is conducted. The following Figure 4.1 depicts the research methodology with the outcomes.

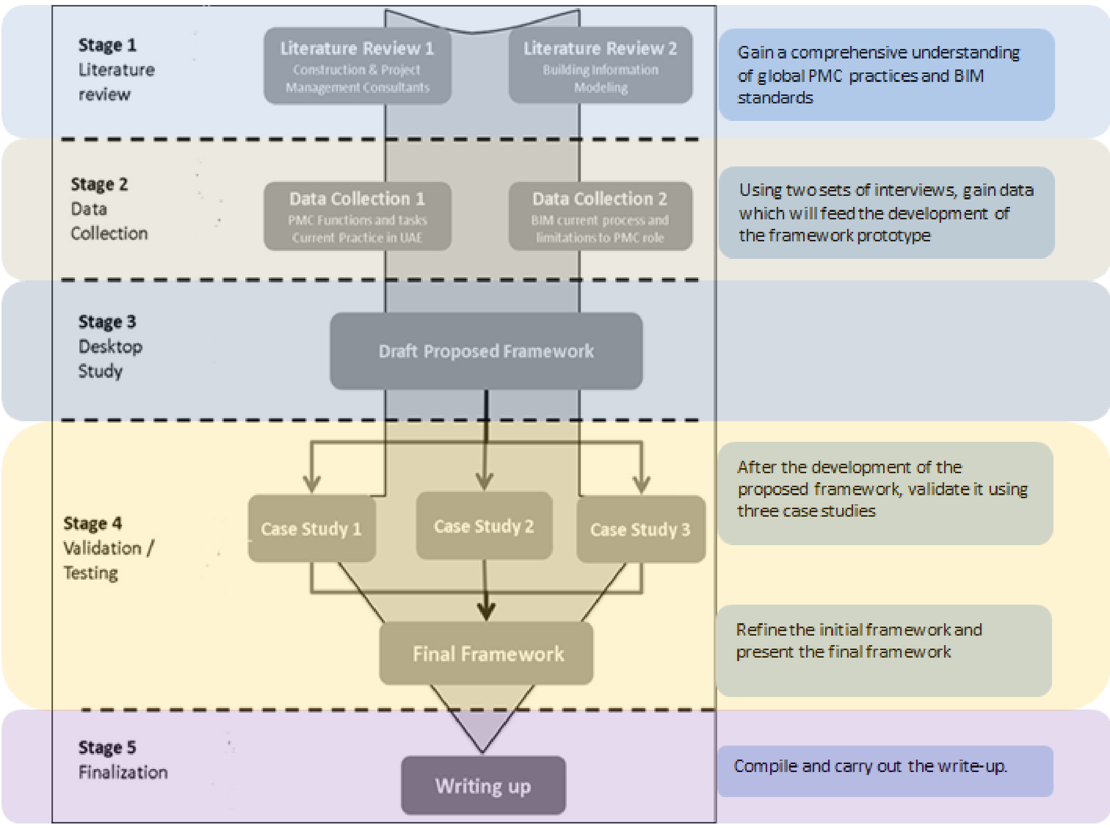


Figure 4.1: Research Methodology Process

4.2 Research Definition

Research could be defined as 'a voyage of discovery', regardless of anything been discovered or not. The deepness of discovery is influenced by search techniques, ability and knowledge of researchers, location and the subject of the research material (Fellows & Liu, 2003). According to Creswell (2003), research is defined as *"The process of making claims and then refine or abandoning some of them for other claims more strongly warranted"*. Singleton et al. (1988) defined research as *"a passive pastime and an important vacation"*. The exercise of research is much more than philosophical assumptions. The philosophical thoughts should be combined to produce research strategies and achieved using precise methods (Creswell, 2003). Fellows and Liu (2003) defined the research method as the strategy of investigation which moves from philosophical ideas to data collection. While in the same context, Kumar and Phrommathed (2005) suggest that if a research study is conducted with the aim of finding answers to certain questions, it should then meet three conditions. These include: (1) the research is conducted within a framework of relevant philosophes; (2) the research explains the procedures, methods and techniques used for enhancing reliability and validity; and (3) it applies a research design that is objective and unbiased. Figure 4-1 illustrates how the research process would work in the idyllic world.

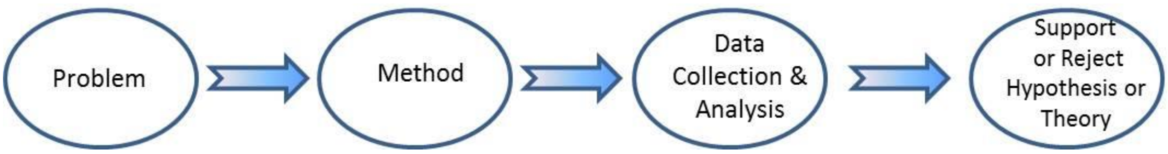


Figure 4-2 Research process (adopted from Bernard, 2000)

Prior to choosing the most effective research methodology for the present research, it is important to discuss the relevant research philosophies and consequently choose one that will guide the rest of the research process. The next section thus discusses and illustrates the most suitable philosophical perspective for this research.

4.3 Research philosophy

Saunders et al. (2012) define research philosophy as the development of knowledge and the nature of that knowledge. Knowledge development in this context entails the creation of a new theory of seeking to provide answers to a specific problem that exists in a particular context.

The present study, for instance, seeks to find answers on how BIM can help support the current practice, roles and responsibilities of PMC.

The adoption of a specific research philosophy shapes the researcher's assumptions about the way in which the phenomenon of interest is viewed. On the basis of these assumptions, the researcher can then choose the most appropriate research methods and strategy to use (Bryman & Bell, 2015). Collis and Hussey (2013) indicate that there are two main assumptions: an ontological and epistemological assumption. In brief, ontological assumptions are concerned with the nature of reliability while epistemological assumptions relate to the nature of knowledge that is acceptable in a given field of study (Krauss, 2005). In this research, epistemology is the most relevant in guiding the research process since it advocates for obtaining knowledge in order to solve an existing problem. For example, existing research is yet to identify the PMC roles within the BIM context and hence the need to create new knowledge in this area through empirical investigations.

Epistemology further includes two main philosophical paradigms/positions which include positivism and interpretivism. The positivism paradigm is based on the assumption that reality exists objectively and in measurable properties (Saunders et al., 2012). Accordingly, positivist studies seek to test the theory with the ultimate aim of increasing the understanding of the relationship between various variables that explain the phenomena of interest. It is for this reason that positivism studies make use of quantitative data that can easily be quantified in order to establish the nature and direction of relationships (Easterby-Smith et al., 2012).

By contrast, interpretivism is based on the assumption that reality is socially constructed is therefore subjective and multiple (Bryman & Bell, 2015). Accordingly, the ability to understand the phenomena of interest and consequently create new knowledge depends on the researcher's ability to understand the views, experiences, beliefs and opinions of the relevant social actors. Put differently; interpretivism contributes to the understanding of the research phenomena through an evaluation of meanings that the study participants assigned to the issue at hand (Arghode, 2012). It is on this basis that interpretivism mainly relies on qualitative data analysis. In this research, the interpretivism paradigm is most relevant since the researcher seeks to understand how the PMC role has been embedded on construction projects that make use of BIM. Ideally, the views on PMC role within BIM are likely to vary from one firm to another and hence the need to obtain diverse perspectives. These perspectives can then be used to provide general guidelines on the role of PMC in construction projects that make use of BIM.

Research indicates that while positivism has dominated epistemological perspectives in the construction industry, the use of interpretivism has increased rapidly in the past few decades. Schweber (2015) for example explains that use of interpretivism in construction-related research has increased significantly following the application of Information and Communication Technology (ICT). The rationale for such increased application is that the use of ICT such as BIM tends to vary across the industry. The experience and meaning of innovations such as BIM also vary significantly across subjects. In addition, ICT use in the industry is dynamic rather than a fixed entity and hence the need for interpretivism research that helps document the sequence of events and contexts.

Before discussing the adopted research methodology for this research, methods in construction research are reviewed briefly with advantages as well as limitations.

4.4 Research Methods

A research method according to (Bryman, 2004) is a technique for collecting data which could involve a certain instrument. For the construction industry, the research methods which are mostly applicable are Survey research, case studies, experimental research, action research and ethnographic research (Fellows & Liu, 2003). Following is a brief review of each method.

4.4.1 Survey Research

Survey research is the method of information collection through asking numerous predefined questions in sequence via organised questionnaire to an example of respondents representing a specific population (Blaxter et al., 2001). The purpose of surveys is collecting information from the sampling frame which includes numeral respondents in order to recognise more definite features among groups. Surveys could be based on probabilistic or non-probabilistic samples and could vary from using structured questionnaires to non-structured interviews.

4.4.1.1 Questionnaire Surveys

The questionnaire survey is one of the most commonly used methods of research with could be used to gather information about any subject from a various number of people big or small as needed. It is mainly a list of questions structured to comply with research needed information. The questionnaire must reflect research objectives through questions which need answers in order to gather the required data for research (Frankfort-Nachimas & Nachimas, 1992). According to (Kumar, 2011; Moore, 1983; Rothwell, 1993) the key advantages of questionnaires are easiness of accomplishment, easiness of analysis, accessibility to respondents and accuracy. Moreover, questionnaires are considered an inexpensive way of data gathering. The questions in questionnaire must be clear and easily understood as typically there is no one to explain the questions further, unlike interviews where there is an opportunity for details' explanation. On the other hand, there are disadvantages for the questionnaire methodology primarily the low rate of response and delay in responses (Kumar, 2011; Moore, 1983; Rothwell, 1993). According to Judd et al. (1991), the quality of collected data is affected by two major factors: response rate which defines the extent of bias from nonresponses, and accuracy and completeness of questionnaire.

4.4.1.2 Interviews

An interview is a conversation between two persons which handled by the researcher in order to gain specific information for a specific purpose related to certain research objectives (Chadwick et al., 1984). Interviews are a commonly used methodology of data collection from people. Interviews are mainly classified into three types: structured, semi-structured and unstructured. Structured interviews are a useful research tool when straightforward data required (Coombes, 2011). It is prepared prior to meeting with the respondent and providing uniform information as needed (Kumar, 2011; Lang & Heiss, 1985). Moreover, structured interviews could be prepared around questionnaire where a clear set of questions directed to the respondent verbally (Bernard, 2000). Semi-structured interviews afford more room for discussion with the recording of respondent views and opinions (Moore, 1983; Coombes, 2001). Such a technique is more appropriate when interviewing elite members of an organisation or community (Bernard, 2000). Unstructured interviews are based on a plan in interviewers mind but not expressed as a discussion is directed based on respondent's responses. The aim of such interviews is to allow respondents express their ideas, experience, etc. with their own terms (Bernard, 2000), and are suitable for researchers with enough experience to gather the necessary data (Coombes, 2001). Interview surveys generally have a big share of common with questionnaire surveys (Moore, 1983). Generally, interviews overcome surveys by the ability to cover a bigger area of application and collecting more in-depth information than questionnaires (Kumar, 2011). Moreover, interviews have a major advantage of providing better opportunities to obtain qualified answer with an ability to clarify the questions not understood be respondent (Moore, 1983; Singleton, 1988).

Both techniques of questionnaires and interviews have advantages and disadvantages in various aspects. Therefore, a brief comparison between the advantages and disadvantages of each technique is presented in the tables below in tables 4-1 and 4-2 (Bernard, 2000):

Table 4-1 Advantages vs Disadvantages of using Questionnaires

Questionnaires	
Advantages	Disadvantages
Low Cost	No control over how people react questions
Same questions to all respondents	Low reliability
Having chances to ask long questions	Not suitable for illiterate
Easy to conduct and quick response	Low response rate

Table 4-2 Advantages vs Disadvantages of using Interviews

Interviews	
Advantages	Disadvantages
Can be used with people who are illiterate, blind, or very old	Costly in both time and money
Having chances to explain questions	A limited number of respondents
Use different data-collection techniques	Needs experience
Long enough to capture valuable information	Subjective

4.4.2 Case Studies

This style of research enables in-depth investigation of particular areas within the subject of research and involves various data gathering methods (Fellows & Liu, 2003). According to Blaxter et al. (2001) case study is a useful method of a subject which is not readily distinguishable from its own context. Heath (1998) defined the case study as *"an account or description of a situation, or sequence of events, which raises issues or problems for analysis and solution".* According to Gillham (2000) case study is defined as "*an investigation of* *specific research questions and range of different kinds of evidence, evidence which is there in the case sitting, and in which has to be abstracted and collated to get the possible answers to the research questions*". Yin (1984) claims that case studies are favoured approach when questions of "how" or "Why" are raised and when the researcher has less control over events or when an area of focus is a real-life context. According to (Heath, 1998) case study could be divided into the following steps:

- Data Collection (Interviews, observations, etc.)

- Restructuring Data (Organizing the structured writing and editing)

- Case Development (supplementary word, audio or video material)

According to (Hamel et al. 1993) case study involves methods including interviews, observation and field studies. Case study data obtained from various sources include interviews, company reports, observations and the researcher's own experience (Heath, 1998; Yin, 1984). In case studies, it is vital that the researcher understand what is required and how to do it (Heath, 1998). An important form of interview for the case study is the semi-structured interview as it is considered one of the richest single source of data for its flexibility (Gillham, 2000). Observation is a basic method of gathering information as well as a selective method of listening and watching to an interaction (Kumar, 2011; Chadwick et al., 1984). Observations could be participant or non-participant ones.

Case study research is not limited to qualitative data and method; it could incorporate quantitative data and analysis into the overall picture (Gillham, 2000). As data are collected from people and organisations; hence the case study research should be able to integrate real-world events with the needed data collection as per data collection plan (Yin, 1984). Consequently, data collection for the research involves the following major tasks:

- Having adequate resources in the field (e.g. recorders, computers, etc.)
- Accessibility to key interviews or organisations
- Having a clear plan for data collection activities
- To be ready for changes subject to availability of interviewees

Reporting phase of the case study is considered as the most difficult part to accomplish, and Yin (1984) recommends combining parts of the case study as early as possible rather than waiting till the end of data collection. The last stage of the research will be evaluating the work been done during the case studies as well the general context of the research. Weiss (1998) has defined research evaluation as *"systematic assessment of the operation and the outcomes of a program or policy, compared to a set of explicit or implicit standards, as a means of contributing to the improvement of the program policy."* Weiss (1972) has defined the necessity of evaluation is *"to measure the effects of a program against the goals it set out to accomplish as a means of contributing to subsequent decision making about the program and improving future programming."* Consequently and according to these definitions; the focal elements of evolution process are operation and results of the program, systematic assessment, standards of assessment and involvement to enhancements. It is evaluator's obligation to produce an evaluation format suitable for the questions and designed to indicate which people or units to be selected, time of comparison will be drawn and timing of investigation (Weiss, 1988). A simple method of data collection during evaluation stage is developing a survey which asking structured and non-structured questions about research topic (Weiss, 1998).

4.4.3 Action Research

This style of research comprises the researcher involved in the process in order to: identify problems, evaluate problems and propose suitable solutions. This kind of research proposes and examines solutions related to particular issues. Modification and innovation are the main focus the research, and close coordination with the participant is crucial for the success of research (Fellows & Liu, 2003; Coombes, 2001). Researches should examine their proposed solution in relation with industry organisations and practitioners (Gittins, 2007). According to Blaxter et al. (2001), the aim of action research is to continually enhance the actual practice. Coombes (2001) defined the action research as study focused on the certain subject of a concern with the aim to implement changes to the current situation. Therefore such type of research is looked at as restricted to "within organisation" one. Action research is considered a substitute to traditional ones as it is based on practice and utilising validity criteria and validation process (Wisker, 2001). According to Wisker (2001), the steps of action research are: attention to the problem, develop a general plan for action, action phase, monitoring phase, collecting data, appraise the outcomes and then reformulate the plan.

4.4.4 Ethnographic Research

Ethnography is *"writing about way of life"* (McNeil, 1990). According to (Flick, 2006) ethnographic research replaced studies via participant observation since the 1980s. This kind of research mainly concerned with studies related to cultures and people and already has it is the foundation in anthropology. Such kind of researches mainly based on a team observes in detail the research subject to gain an insight into how what and why behaviours accrue by people. McNeil (1990) has defined the drive of such kind of research is *"to describe the culture and lifestyle of the group of people being studied in a way that is as faithful as possible to the way they see it themselves"* The crucial elements of ethnography research are interviews, observation and investigations in order to understand the respondents perspective (Fellows & Liu, 2003). Ganah (2003) argues that the strength of this methodology of research arises from producing novel ideas and visions while its weakness arises from the subjective nature of the process. Another primary disadvantage for this kind of research is that its nature is time-consuming as it takes researchers' full time (McNeil, 1990).

4.4.5 Experimental Research

This method of research is suitable best for bounded issues or problems where the related variables are recognised or hypothesised. Generally, experiments are accomplished inside laboratories and targeting examination relationship between defined variables (Fellows & Liu, 2003). The nature of experiments involves the maximum validity of research over the design and procedure and unlike field experiments; laboratory experiments are poorly representing the natural process (Judd et al., 1991). Moreover, it is not possible to control all the potential variables in field experiments (McNeil, 1990). A major criticism of experimental research is that an experiment does not provide helpful expressive data like surveys. Although surveys deliver expressive data of population, experiments are delivering information for reasons and impacts while it does not provide descriptive data for percentages of people in the population (Judd et al., 1991). Table 4.3 provides a summary of the relevant situations for the different research methods.

Table 4.3: Relevant situations for application of the different research methods (Yin, 2009)

Strategy	Form of research question	Requires control over behavioural events	Focuses on contemporary events
Experiment	How, why	Yes	Yes
Survey	Who, what, where, how many, how much	No	Yes
Archival analysis	Who, what, where, how many, how much	No	Yes/No
History	How, why	No	No
Case study	How, why	No	Yes

4.5 Research Approaches

Research approaches commonly categorised under one of the three main categories: qualitative, quantitative and mixed (triangulation) approaches (Creswell, 2003). The quantitative approach principally utilises post-positivist claims for developing information such as for cause and effect thinking, use of measurement, reduction to specific variables and hypotheses and observation and testing of theories. It also utilises selection approaches for inquiry (i.e. experiments and surveys and accesses numerical data) (Creswell, 2003; Fellows & Liu, 2003). Quantitative research is also a kind of research in which the data is in numbers form (Blaxter et al., 2001)

The qualitative methodology is established on constructive perceptions (i.e. several meanings of specific experience, meanings historically and socially constructed, etc.) or advocacy / participatory viewpoint (i.e. collaborative, issue-oriented, political or change-oriented) (Creswell, 2003). According to Blaxter et al. (2003) qualitative research is the type of research where data are not in the form of numbers. Another definition of qualitative research is by Chadwick et al. (1984) where it is defined as *"several different modes of data collection, including field research, participant observation, in-depth interviews, ethnomethodology, and ethnographic research."* In qualitative research, the investigation of the study subject is not taking into consideration the past formulations as it aims to gather data and information for future evolving theories. Therefore, qualitative research is considered a precursor to the quantitative research where the collected data could be unstructured (Fellows & Liu, 2003). The limitations of the quantitative research approach are considered a preparatory point to adapt qualitative research as the main ideas surrounding qualitative research are different from those in quantitative research (Flick, 2006).

According to Blaxter et al. (2001) and Bryman (2004), there are differences and similarities between the qualitative and quantitative researches as follows:

- Quantitative research commonly utilised for testing theory; while it could also be used for exploring a subject and creating hypotheses and theory.
- Qualitative research could be used for testing theories and hypotheses. However, it is commonly utilised for theory establishment.
- Qualitative data often include quantification (i.e. statements such 'most', 'more than 'less than', etc.).
- Quantitative research methodology could gather qualitative data through open-ended questions (i.e. in large-scale surveys)
- Quantitative data are commonly called 'hard' as it is strong and have accuracy which is offered by measurement. However, qualitative researchers' involvement results in more in-depth and rich data.
- In qualitative researches, researchers usually seek close involvement with respondents under study. But in quantitative research, researchers are concerned about their subjectivity. Hence they are not involved in their subjects.
- Qualitative researches are usually related to small-scale aspects of social reality. While Quantitative researchers are commonly involved a large-scale connection between variables.
- Qualitative research is consistent with the actions of participants of social settings whereas quantitative research is considered as a static image of social reality with its highlighting on relationships between variables.

The above differences and similarities between quantitative and qualitative researches are illustrated in table 4-4 below.

Table 4-4 The differences between qualitative and quantitative research (adapted from Blaxter et al., 2001; Bryman, 2004)

Qualitative	Quantitative
Subjective	Objective
Theory emergent	Theory testing
Natural and uncontrolled observations	Controlled measurement
Process-oriented	Outcome-oriented (static)
Dynamic reality and un-generalised	Stable reality and generalised
Close to the data: inside perspective	Concluded from data: more outside perspective
Rich and in-depth data	Hard and reliable data
Micro	Macro

The mixed approach (triangulation) utilises the strategy of data collection either sequentially or simultaneously to best understand research questions. Flick (2006) defines triangulation as a combination of both qualitative and quantitative methods. Such an approach utilises both textual (interviews) and numeric (i.e. surveys, instruments etc.) as techniques for data collection. Triangulation method considered as useful in order to gain results and to assist in making drawings and interfaces conclusions (fellows & Liu, 2003) which is demonstrated in Fig. 4-3 below.

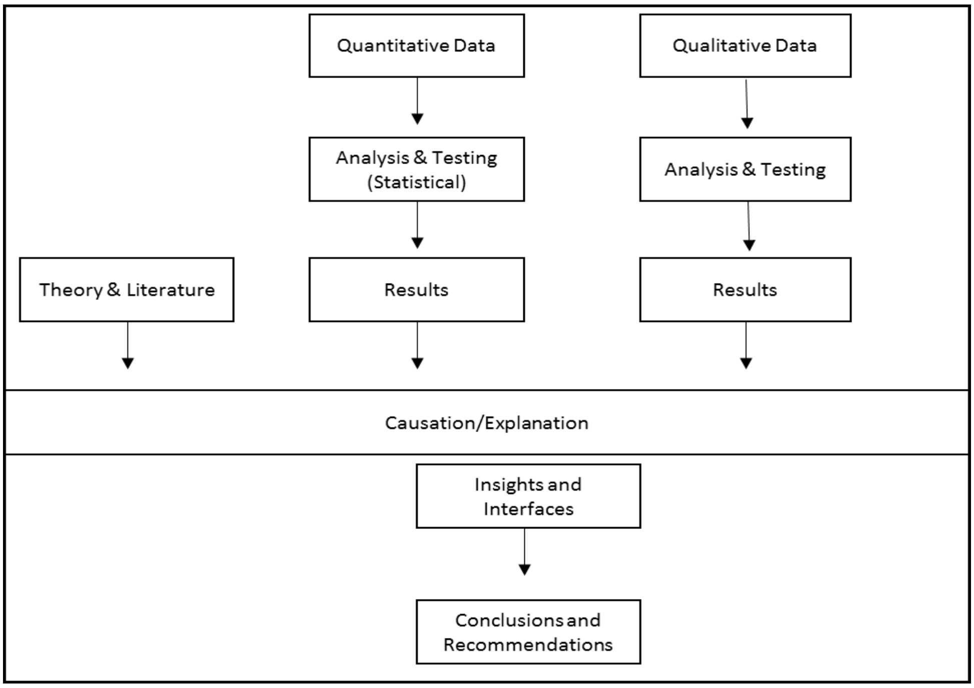


Figure 4-3 Triangulation approach

4.6 Deductive and inductive approaches to research reasoning

Deduction as an approach to reasoning in a research study involves the development of a theory which is subsequently subjected to the rigorous test. As explained by Collis and Hussey (2003) deductive approach is most common in natural sciences since the field is characterised by the presence of laws which determine the basis of explanation and also make it possible to anticipate and predict the relationship between the study variables. The deduction approach involves five main steps: generation of hypothesis from existing theory; expression of hypothesis in operational terms; testing of the operational hypothesis from the empirically collected data; examination of the specific outcome of the inquiry which forms the basis of confirming or realizing the need for modification; and lastly the modification of existing theory if necessary (Saunders et al., 2012). Therefore, the deductive approach follows a "top-bottom" in which case the researcher moves from the more general to more specific aspects of the research.

The alternative approach of inductive research is mainly popular in social research and seeks to formulate a new theory as opposed to establishing a cause-effect link between variables. Researchers are adopting the inductive approach generally follow a "bottom-up" sequence by moving from the more specific observations to making broader generalisations and theories. In other words, the conclusions made are based on the premises (Fereday & Muir-Cochrane, 2006). The present research mainly adopts the inductive approach since it allows for the development of a framework on how PMC role can be integrated into BIM. In this case, investigations from the various case studies form the basis on which generalisations on PMC role in BIM are put forward. One of the benefits of using the inductive approach is that it is less rigid (Hyde, 2000). As a result, it allows the researcher to obtain and incorporate alternative explanations on how well PMC roles fit into BIM. To a lesser extent, the deductive approach is also incorporated in the present study. The researcher, for instance, evaluates how well the findings from the case studies fit into the reviewed literature.

Table 4-5: The main differences between deductive and inductive approach (Adapted from Saunders et al., 2009)

Deductive approach	Inductive approach
Based on scientific principles	Seeks to facilitate an understanding of the meaning that individuals attach to events and situations
Moves from theory to specific context/data	Commences with development of a close understanding of the research context and proceeds to making of theory
Anchored on the need to explain causal relationship among variables	Entails the collection of qualitative data
The collection of quantitative data	Adopts a more flexible structure that permits making of changes to the research process
Involves application of controls in order to ensure reliability and validity of data	A realisation that the researcher is part of the research process
The operationalisation of concepts to ensure clarity of definition	Less concern with the need to generalise
A highly structured approach	Less structured approach
Researcher's independence of what is being researched	
The necessity to select samples of sufficient size in order to generate a conclusion	Low focus on generalisation of the study results

4.7 Research strategy

Research strategy constitutes the general plan of how the researcher seeks to meet the study objectives or provide answers to the research questions (Saunders et al., 2009). Research strategy has also been defined as the logical plan for getting to an intended conclusion as well as the inclusive plan that the researcher adopts in order to provide answers to the research questions and consequently satisfy the study's aim and objectives (Yin, 2003; Creswell, 2009). Choosing the right research strategy constitute an important aspect of the research process since it has implications on how investigations are to be conducted. Within this context, Collis and Hussey (2009) and Yin (2003) identify four types of research strategies which include descriptive, exploratory, explanatory and analytical strategies. This section reviews each of these strategies and provides justification for the chosen strategy.

Descriptive research

Descriptive research is undertaken in contexts where there are a good structure and understanding of the research problem. While using this strategy, the researcher mainly seeks to provide a description of the research phenomena thus enabling the readers to have a comprehensive understanding of the issue at hand (Merriam & Tisdell, 2015). In other words, the descriptive research seeks to provide an accurate portrayal of events, situations or people. This is achieved by finding answers to questions related to 'what is going on?' in a certain field of interest. By helping identify important variables in a given study, descriptive research can be a precursor of future research. The main shortcoming of descriptive research is that it does not allow for determination of cause and effect relationship (Easterby-Smith et al., 2012).

Exploratory research

Robson (2002) explains that exploratory studies constitutes a value means of finding out issues happening in the field of interest, seek new insights, pose questions and assess phenomena of interest in new light. This strategy is particularly important when the researcher seeks to clarify an understanding of the problem and is unsure of the precise nature of the research problem at hand (Saunders et al., 2012). According to Zikmund et al. (2013) exploratory is further useful when the research at hand is characterised by the minimal availability of information. It is for this reason that some of the main purposes of exploratory research including a screening of alternatives, the discovery of new ideas and diagnosis of a situation. In terms of application, Collis and Hussey (2009) indicate that exploratory research can be used in case studies and historical analyses that make use of both quantitative and qualitative data.

Explanatory research

In explanatory research, the main purpose is to establish and explain the nature of the relationship between the various study variables (Robson, 2002). This requires the application of statistical tests to the collected data in order to obtain correlation results that confirm the presence or absence of a relationship between the variables. While explanatory research has mainly been associated with quantitative studies, it can still be applied in qualitative studies to find out why individuals or organisations act in a specific way (Saunders et al., 2012).

Based on a review of the above research strategies, the present research was conducted based on a combination of exploratory and explanatory research strategies. Exploratory research was deemed to be highly suitable since there is a dearth of research on how PMC role fits into the concept of BIM in construction projects. Accordingly, exploratory research was conducted with the aim of gaining deeper insights based on the views of industry experts. The resultant findings were then used to propose a framework which highlights areas where BIM can best support the PMC roles and responsibilities. The explanatory strategy was, on the other hand, deemed important in facilitating an understanding of the relationship between BIM and specific PMC roles. This aspect was instrumental in the validation of the proposed framework as well as understanding how various case study organisations would apply the framework based on their need.

4.8 Adapted methodologies and Justification

The decision has been taken for this research is a combination of qualitative and quantitative approaches. The methodology was designed to investigate the current practice roles and responsibilities of PMC with focus on achieving and a new framework for BIM management with PMC role. Furthermore, it was taken into consideration that combined research would enable the findings from each stage of the study to inform and refine following stages as well support reliability and validity of the research. Table 4-5 summarises the overall research strategy and methodology for this study as follows:

Table 4.6 – Summary of overall research strategy and methodology

Aim	
To develop an optimum BIM management framework enhancing the PMC's role & practice in UAE construction industry	
Objectives	Methodology
Review construction industry performance and PMC role	Literature review - Construction Industry development and current performance. - Construction industry strategic issues - PMC role evolution - PMC advantages/disadvantages and role and practice
Review Building information modelling evolution	Literature review - BIM evolution - BIM as contemporary solution for construction projects - BIM uses
Explore PMC's current functions and frameworks and identify key functions which can be best supported by BIM	Draft current PMC role framework - Semi-structured interviews with industry experts for identifying the exist framework and identify areas where BIM can best add value
Propose a holistic framework supporting main PMC functions utilising BIM to get maximum value of BIM	Draft Framework proposal / Scenario generation - Identifying the PMC role and responsibility for BIM implemented project
Validate the proposed framework	Interviews - Evaluating scenarios and implementation of framework with potential users for different function within each organisation.

4.8.1 Literature review

The research process is about collecting data and processing it into information (Moore, 2000). The primary start point of the research is the literature review which is commonly named as "desk research". A literature review mainly aims to review previous works in the area of the research subject and to justify the current research. A literature review is considered as a continuous process which begins before the research problem finalisation and continues till research completion. Literature review is bringing clarity required to support research methodology. The main sources for literature review are published books, reports, journal articles recent conference papers, reports and published theses (Creswell, 2003; Blaxter et al., 2001; Kumar, 2011). Today, the internet and different research databases are the main sources for the above-mentioned publications (Blaxter et al., 2001).

A literature review was undertaken to investigate issues with the construction industry, Project Management Consultants evolution and their role, Building Information Modeling development.

4.8.2 Semi-Structured Interviews

Semi-structured interviews with industry experts were used in this research. The interviews will aim to get a real data from industry about the framework of PMC role, duties and responsibilities for their functions and identify key functions where BIM could enhance the current practice and performance. The gained data will assist in drafting the initial framework for PMC role, duties and responsibilities in the presence of a BIM model in the project.

4.8.3 Scenario generation / Case studies

A virtual scenario will be established for the developed framework which shall be examined through case studies. The case study will be based on detailed interviews with industry representatives. For each case study, the interview will be done with concerned personnel related to certain function in order to validate the scenario for the proposed function framework. The comments from each person will be adapted into the framework and by the end of interviews of different personals in the same organisation; a refined framework will be produced prior to proceeding with the second row of interviews with a different organisation for more validation.

4.9 Sample Size

Due to limited number of PMC in UAE, This research covered big scale PMC as approaching small scale PMC organizations will not benefit and will negatively affect the research. Accordingly, most interviewed companies had 100+ employees. The sample size consists of experts in the Construction Industry and project management organization which server the purpose of this reserach. According to Kvale (2008), when interviewing experts in any given field, the sample size can be less than 15 but more than 2. Thus, in this study, there is varying number of experts chosen from different firms in the Construction Industry to provide inputs into the role of PMC.

4.10 Data analysis techniques

In consistency with the choice of interviews as the main source of data, the present research makes use of thematic content analysis to identify and present the key study findings. Thematic content analysis has been defined as the identification, analysis and reporting of patterns that emerge within the collected data (Braun & Clarke, 2006). Using this analysis technique the research organises and describes the data set in richer detail for purposes of further interpretation. A theme in qualitative analysis captures an important thing about the data in relation to the set research questions or objectives as well as the presence of patterned responses in the dataset (Hsieh & Shannon, 2005).

In order to facilitate the identification of relevant themes, the present study made use of open coding. This approach to qualitative analysis involves labelling concepts, defining and developing categories on the basis of their various dimensions and properties (Elo & Kyngäs, 2008). For example, similar responses (based on words used by interviewees or intended meaning) from the various case study interviews were highlighted using the same colour code and later analysed with the aim of understanding the underlying meaning being created (Thomas, 2006). This process requires the analysis of the various codes in order to find similarities which can be grouped into categories. In the present research, such categories mainly represent PMC roles within the BIM framework. The identified themes were then substantiated based on the literature on PMC roles and BIM and generalised for application in a wide range of construction projects that utilise BIM.

4.11 Reliability and validity

Reliability and validity constitute important aspects of the research process that help ascertain the extent to which quality research findings have been developed. Reliability has been defined as the extent to which results from a given study are consistent over time and also constitute an accurate representation of the total population under study (Drost, 2011). As such, reliability is considered to have been attained if the study results can be reproduced if the similar methodology is used. Validity, on the other hand, determines the extent to which given research truly measures the intended measures. In other words, validity entails the extent to which the study results are truthful (Golafshani, 2003).

There has been a debate regarding the extent to which reliability and validity are applicable research that makes use of qualitative data such as interviews. One of the issues of concern is that reliability and validity are embedded in the positivist paradigm that is associated with quantitative research. For example, quantitative research emphasises on replicability and repeatability of results and observations and hence the need to ensure that the measurement instruments (e.g. questionnaire) used are consistent (Charles, 1995). By contrast, qualitative research focuses mainly on understand a situation or phenomena in order to generate new meaning. This means that the research instruments used are specific to the given research study and hence the problem of replication.

Notwithstanding the differing views, a growing number of studies have emphasised that reliability and validity are equally important in qualitative research but may necessitate a different approach from that of quantitative research. Healy and Perry (2000) for example assert that reliability in qualitative research should be approached from the perspective of whether the study results are credible, neutral and confirmable. Similarly, Seale (1999) argues that reliability in qualitative research is highly applicable and essential and should mainly focus on the extent to which data is consistent. According to this author, consistency in qualitative research can be achieved by ensuring that the steps undertaken during the research process are verifiable through the examination of items such as raw data, data reduction products and process notes. In the present research, this was achieved by ensuring that raw interview data on PMC role in the context of BIM was provided in the appendix and that the process used to extract useful insights from these data was well illustrated.

The concept of validity has also been redefined in qualitative research. Stenbacka (2001) indicates that validity in the qualitative perspective mainly relates to rigour and trustworthiness. This requires the researcher to ensure that the results are more credible and defensible. In the present research, validity was achieved in a number of ways. First, the appropriateness of the questions posed in the interviews was verified with an expert in the study subject. This expert specialised in the area of project management consultancy and had sufficient knowledge about BIM. Second, the problematic questions in the interview guide were modified or removed with the aim of ensuring that all questions were well aligned with the research questions. Third, each of the respondents was contacted early in order to ensure adequate preparation for the interview sessions.

4.12 Research ethics

Ethics in a research context refers to the moral values and principles which constitute the basis of the code of conduct during the research process. It revolves around the approach through which the research is conducted, and results are reported (Collis & Hussey, 2014). Six principles have been identified as relevant to research ethics. The first principle revolves around the need to minimise the risk of harm or discomfort to participants during the course of undertaking the study (Gerrish & Lathlean, 2015). In this study, no risk of harm was anticipated to the participants. The researcher was however aware that some respondents would be uncomfortable to discuss sensitive internal process revolving around PMC and BIM. This risk was minimised by ensuring that only non-intrusive questions were posed during the interview sessions.

The second principle refers to the need to obtained informed consent from the research participants. The general aim is to ensure that all participants have an adequate understanding of the purpose of the research and what the research requires of them (Crow et al., 2006). Such consent was obtained by providing the respondents with a consent form that included all important information about the research. The third principle of research ethics requires the research to protect the anonymity and confidentiality of the study respondents (Wiles et al., 2008). The respondents, in this case, have the right to expect that the information they provide will be kept in confidence and that the reader of the final study should not be able to link the respondents to their data. Accordingly, the interviewees from the various firms from which information about PMC role and BIM was obtained were informed that no personally identifiable information such as address and name was required. In relation to confidentiality, the respondents were informed that only aggregated responses would be included in the main research.

The fourth principle relates to avoidance of deceptive practices. Such practices may include failure to provide important information about the study's purpose (Smythe & Murray, 2000). Such deception was avoided by ensuring that all respondents were genuinely informed about the study. The fifth principle, on the other hand, relates to the provision of the right to withdraw (Garner & Scott, 2013). While all respondents were encouraged to complete the interviews they were informed that they could choose to withdraw from the research at any stage without giving reasons. The sixth principle was in relation to sharing and dissemination of the results. According to Greaney et al. (2012), it is inappropriate for researchers to withhold the research results from the respondents. Accordingly, participants were asked if they required a copy of the final study findings. Those who consented were required to provide an email address for the sharing of the results.

4.13 Chapter conclusion

To conclude, this chapter explored the various research methods and strategies that are available to the researcher. Before commencing any research, the research philosophy needs to be defined in order to facilitate the research process. In this research, epistemological (interpretivist) philosophy was applied whereby this research sought to develop a comprehensive understanding of how BIM can change the current practices in the construction industry of the PMC. Using empirical investigations, this study created pertinent information as to how the role of PMC can be integrated via BIM. The methods employed in the research are semi-structured interviews and case studies. Using two sets of interviews this study gained invaluable information into the current practices of the PMC and what the ideal scenario should look like respectively. Thereafter, the case study method is applied to validate the results generated from the interviews. This study primarily incorporates an inductive approach with a minor hint of a deductive approach. Using the literature review, two sets of semi-structured interviews and case studies, this research combines several methods to develop a comprehensive and validated result that is reliable and authentic.

Chapter 5

Development of framework prototype

5.1 Introduction

The fieldwork of the present research comprised of two main stages: data collection stage and validation/testing of the proposed prototype stage. The first stage involved collecting data and comprised of two steps. The first step investigated the current practices for PMC role, duties and responsibilities as well as reflected these practices on the RIBA plan of work. The second step involved exploring the current shortfalls in PMC involvement in current BIM process and offering recommendations for proposed involvement. The second stage of field work involved proposing a prototype for a framework as well as validating it through case studies.

This chapter seeks to discuss in detail the first stage: data collection. Accordingly, it investigates the current practices of PMCs in the UAE and relates them to the RIBA plan of work as well develops recommendations for proposals of PMCs' BIM related role. In order to achieve this objective, structured interviews were conducted with representatives of some of the main PMC organisations in the UAE. This chapter will, hence, discuss the proposed data collection methodology with justifications as well the path followed to accomplish this stage including drafting the interview questions, the selected interviewees, as well as the collected data and analysis. The chapter concludes with a reflection of current practice over RIBA Plan of Work and recommendation for framework proposal. The flowchart below visualizes the process in brief.

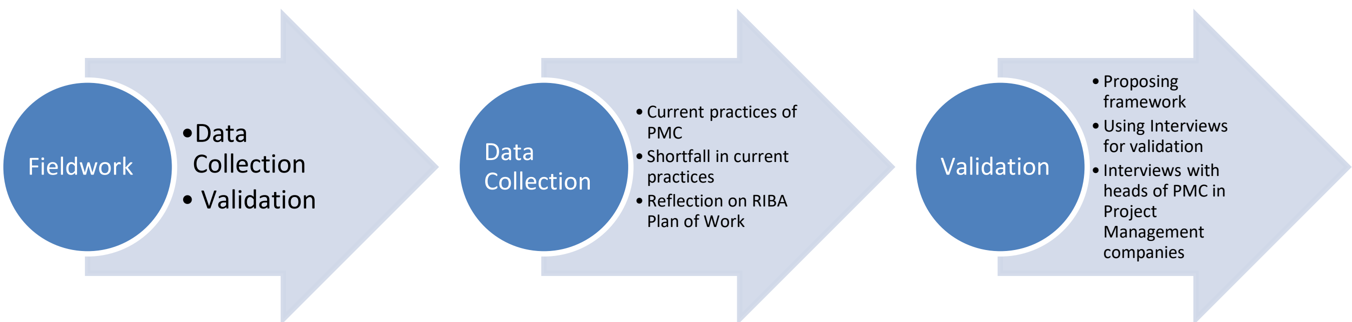


Figure 5.1 Framework development flow chart

5.2 Data Collection – Research Methodology and Justification

According to (Moore, 2000), a research process is about collecting data and processing it into meaningful information. This definition of research is directly applicable in the present context where gathering insightful information of the current practices in the local industry of PMCs in the UAE is deemed necessary. This approach is in line with what was discussed in the previous chapter of research methodology where the research process was reflected as follows.

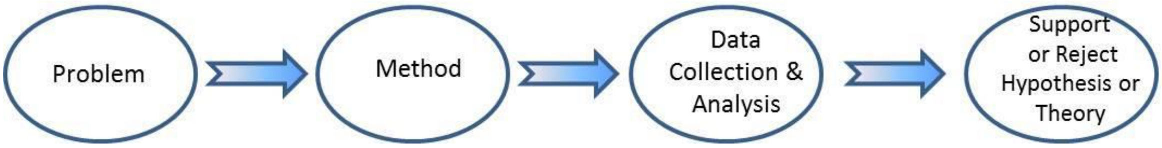


Figure 5.2 Research process (adapted from Bernard, 2000)

There are two main reasons why such data collection is required. First, the lack of statistic and published data pertaining to the subject of research, and second, lack of standards defining bases for PMCs practice in the region.

After studying different research methodologies in chapter 4, several reasons informed the need to conduct interviews as opposed to the use of survey questionnaires.

First, the key advantages of interviews is providing a researcher a chance to explain the questions, use different data-collection techniques and is long enough to capture valuable information. Bernard (2000) described several advantages and disadvantages of using questionnaires and interviews; some of which are listed below.

Advantages of Questionnaires:

- Low cost
- Uniformity of asking the same questions to all the respondents
- The provision to ask long, open-ended questions.
- Generates quick response and is easy to conduct

Advantages of Interviews:

- They can be conducted with visually impaired individuals, illiterate or elderly individuals
- The questions can be explained to the interviewee

- The data collection techniques can be different
- Important information can be captured with ease

Disadvantages of Questionnaire:

- There can be no control over the reaction of people
- It has a low reliability rate
- Cannot be applied to a person if they are illiterate
- There is a potential for a lower response rate

Disadvantages of Interviews:

- It can be resource-intensive in terms of time and money
- The pool of interviewees will be limited
- The individuals must be experienced
- It is highly subjective

Second: As explained by Kumar (2011) interviews overcome surveys by the ability to cover a larger area of application and collecting more in-depth information than questionnaires. The respondents are, in this context, not limited to pre-selected responses which are popular in surveys.

Third: interviews have a major advantage of providing better opportunities to obtain qualified answers with the ability to clarify the questions not understood by the respondent (Moore, 1983; Singleton, 1988)

Fourth: the number of well-established and accessible PMC organisations in the UAE is relatively small. UAE Results suggest that there are about 40 PMC organisations in UAE but only less than 20 fully specialise in offering consultancy services to medium and large construction/building projects. The relatively small number means that it could not be possible to undertake a representative study within the recommended margin of error for quantitative studies.

5.3 Design of the data collection instrument and sample considerations

As aforementioned, the interview was preferred since it allows for in-depth responses to be obtained from the interviewees. However, according to Coombes (2011), interviews are classified into three types: structured, semi-structured and unstructured. As discussed in the previous chapter of research methodology, structured interviews are prepared a prior meeting, providing uniform information (Kumar, 2011), could be prepared around questionnaire (Bernard, 2000) and considered as a useful tool when straightforward data is required (Coombe, 2011). The unstructured interviews are mainly based on an in-mind plan which is not expressed directly as the discussion would be changed based on interviewees responses (Bernard, 2000).

Semi-structured interviews afford more room for discussion with a recording of respondents views and opinions (Moore, 1983; Coombes, 2001). Such a technique is more appropriate when interviewing elite members of an organisation or community (Bernard, 2000). In light of the aforementioned characteristics of different types of interviews; the semi-structured interviews arise as most suitable for this research for the following reasons:

First: The research aims to propose a holistic framework to cover the various aspects of PMCs role through different stages of a projects life cycle. Hence the selected interviewees are to be in the position of Director or Project Manager.

Second: this design includes ease of comparison of responses since similar questions are posed to all interviewees.

In order to ensure that data was collected from the most relevant respondents, the researcher made use of purposive sampling. This sampling technique, as Saunders et al. (2012) explains, enhances the credibility of responses by ensuring that data is only collected from individuals who have expert knowledge regarding the field under investigation.

In order to achieve the desired objectives of the data collection stage, two circles of interviews been designed to serve two main objectives: Exploring current roles and responsibilities (Interview A) and investigate recommendations for overcoming current gaps in BIM practice by PMCs (interview B).

The objective of conducting the interviews is to gain information which will aid in the development of a strategic framework of the BIM functions and tasks. These interviews were structured into two parts with the first part aimed at understanding the business activity and the second part aimed at uncovering the limitations and understanding the ideal BIM framework. The interviewees belong to organisations, PMC's, and the leadership of the organisations in question.

5.4 Interview A

A two-part interview structure was used in the interview protocol.

PART 1

This part involved asking about the company business. The aim was to ensure that the core practice of the firm was within PMC. The questions asked are provided below accompanied by a brief description of the reasoning.

5.4.1 Interview (A) questions design

A two-part interview structure was used in the interview protocol.

Part One: involved asking about the company business. The aim was to ensure that the core practice of the firm was within project management consultancy. The questions raised at this area were as follows:

Q.1. How you describe the core business of your organisation?

The aim of this question was to ensure that the interviewed person represents a company working in the field of PMC or at the PMC division of the corporation if the company is multifunctional corporate.

Q.2. What is your position within your organisation?

The aim of this question was ensuring that the interviewed personnel work in a senior position with the organisation such as Project Director or Project Manager. The choice of these positions was deemed necessary in order to ensure all responses reflected a full understanding of the role of PMC in all phases of building projects' lifecycle. Selection of representatives of mid-level positions would give inadequate responses as their views would be limited to their roles.

Q.3. For how long your company has been practising as Project Management Consultants?

This question aimed to identify the experience of the PMC in order to gauge the relevance of the responses. New companies in the business would not represent the best example of practice as well as challenges associated with it. Moreover, corporates with limited experience in the field of research would provide less justified prospectives for recommendations in the third part of the interview.

Q.4. What is the average percentage for projects adapting BIM within overall running projects of your organisations' portfolio?

The aim of this question to identify companies where BIM is already been used and consequently those companies could be targeted for interview B at a later stage of this research.

PART 2

Part two of the interview questions was investigating the current roles and responsibilities for project management consultants at each stage of the projects’ life cycle. Accordingly, the following questions were asked of the interviewees:

Q.5. How do you describe stages of a project where your company services are usually provided?

This question aims to understand the project stage breakdown and definitions used in real practice with the local region as it might vary from an academic perspective.

Q.6. At what stage usually project management consultants are hired by clients?

This question investigated clients’ perspective of the project management role and value which would involve affecting decision-making on project’s strategic level (i.e. procurement route).

Q.7. What is the role of the project management consultant at the pre-design stage?

This question and the following questions 8 and 9 will form the core of this data collection. The objective is to identify the duties and responsibilities at each stage while the interactive discussion translates the provided information into the framed shape of functions and tasks.

Q.8. How do you describe project management consultants’ roles and responsibilities at design stage of project’s life cycle?

Q.9. What are the roles of project management consultant at execution stage?

Q.10. Should project management consultants be involved during the project handover stage?

Q.11. Should project management consultants be involved during the operation stage of the project lifecycle?

The above questions from 8 to 11 investigate the extent to which the client would involve the PMCs beyond the actual execution stage.

5.4.2 Interview A responses and analyses

The value of each research comes from its outcomes. The aforementioned data collection approach and process needs to be translated into valuable, measurable, qualified and quantified information. Therefore, the following part of this chapter will provide the outcomes of the collected data as well as the analysis.

The exact transcript of the undertaken interviews will be provided in the appendices. However; the following is the findings from the interviews pertaining the three parts of interviews described above.

Interview Part 1:

Q.1. How you describe the core business of your organisation?

Ten organisations were interviewed in this part. However, not all organisations had their business as solely project management consultants. It was noticed that half of the interviewed organisations were established and operated solely as PMCs. Nearly 40% of companies were functioning as Architect and Engineering firms where the PMC division was an added later to the functions of the company. Only one company was functioning as Cost Consultant and added the PMC division.

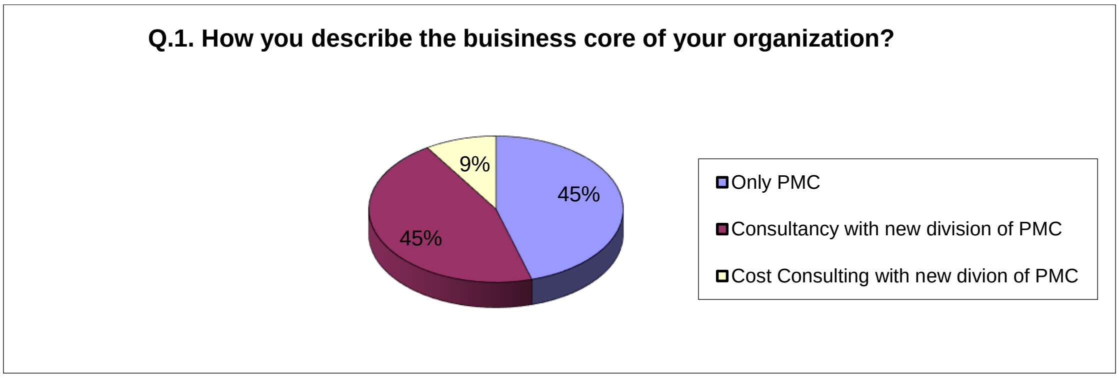


Figure 5.3: Core business of the organisation

In order to get relevant insights pertaining to pure PMC roles, it was emphasised during the interviews that the respondent should be working for the firm's PMC division and the respondent should belong to the PMC division and operate in isolation from the other divisions of the company. Typically, the interviewees have been advised to respond to the questions with an example of projects where their role was the PMC only in the project.

Q.2. What is your position within your organisation?

The selected interviewees were in senior positions within their organisations. 70% of the interviewees were working as Project Directors while nearly 20% were Project Managers. Only in one case, the interview was with a Deputy Project Manager.

Q.3. For how long your company has been practising as project management consultants?

The findings for this question provides an overview of years of experience the company been practising the role of project management consultants.

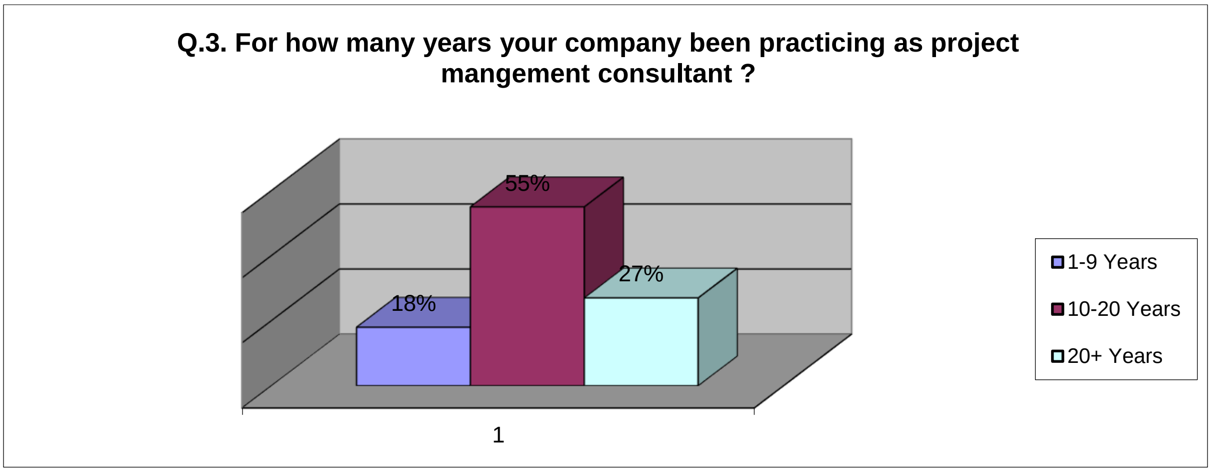


Figure 5.4: Years practising as a project management consultant

Q.4. What is the average of percentage for projects adapting BIM within overall running projects of your organisations' portfolio?

Approximately 70% of the interviewees stated that BIM is used in their projects. However, they also stated that clients are involved in the decision to use BIM, and hence, not all projects would involve BIM.

The following chart reflects the percentage of projects utilising BIM according to the interview findings.

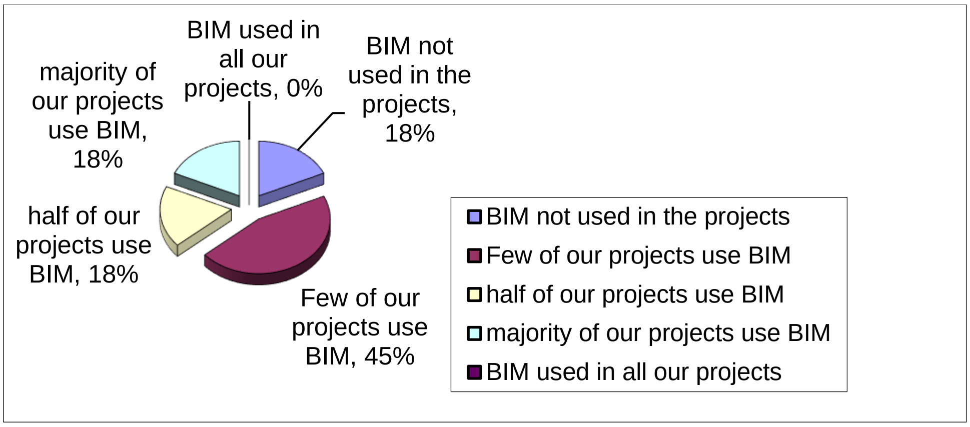


Figure 5.5: Percentage Use of BIM

Interview Part 2:

Q.5. How do you describe stages of project where your company services are usually provided?

The finding for this question was unified between all participants in this study. They all agreed that the stages of each construction project they have participated are the following: Pre-Design stage, Design stage, construction stage (execution), handing-over stage and finally, the operation stage. It was agreed by all participants that PMC do not have any role for the operation stage as their role ends by the handing over the stage.

Q.6. At what stage usually project management consultants hired by clients?

The finding of this question was interesting as the majority of interviewees agreed that client involves them at different stages and not necessarily at the same stage each time. Consequently, the discussion leads to asking what percentage of the project the client would typically involve the project management consultant. The findings are illustrated in the following chart. The usual practice is to hire the PMC consultant at the construction stage to solve a recurring problem. However, around 27% involved a PMC at the design stage. Some respondents stated that theideal scenario would be the hiring of the PMC at the pre-design stage. 18% of the respondents stated that they were hired at the pre-design stage.

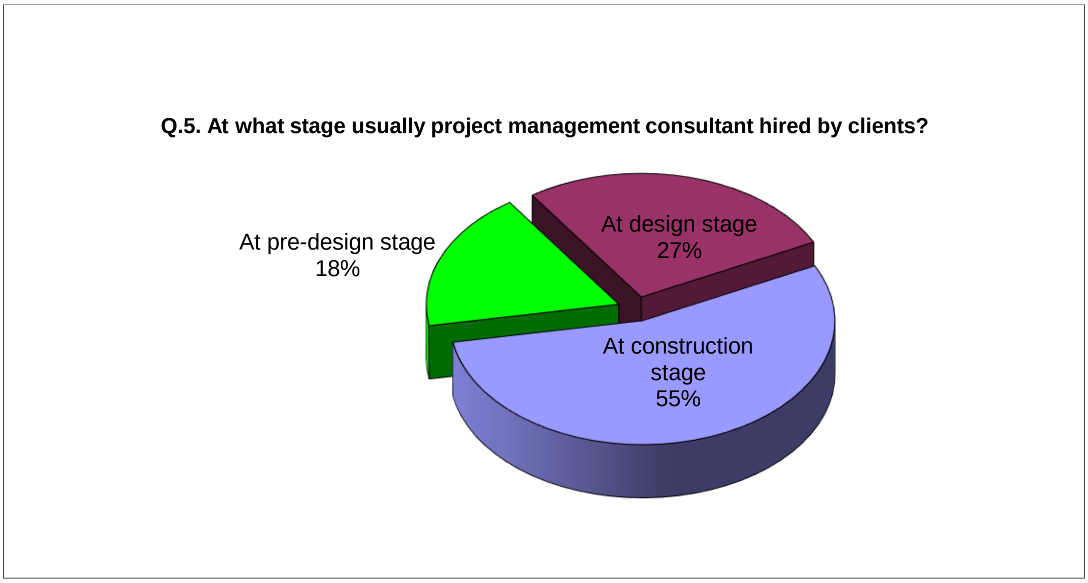


Figure 5.6 Project management consultant is hired by the clients at various stages.

Q.7. What is the role of the project management consultant role at the pre-design stage?

This stage was named as the 'preparation' stage by almost all the interviewees. All interviewees agreed that their role would be providing necessary support to the client in drafting the scope of the project as well as support by utilising their experience in drafting necessary contract conditions of the designer. At the same time it was also agreed by all participants that they would not have a decision or influence in design decision while they would have influence in managing the overall tender stage for the selection of designers. These findings agree with literature findings in previous chapters of this research where PMCs have been described as *"clients' advisor who leads the project"* according to the definition by Chartered Institute Of buildings (CIOB. 2002). Also, the respondents agreed with Nitithamyong & Tan (2007) where they clarified that PMC only performs PMC services and does not carry out any construction or design works.

The findings presented two primary functions which were contract management and recommendation for a design competition and tendering. The contract management function had two subsidiary tasks. Task 1 is recommending contract conditions for the future designer by utilising the experience of commercial manager for scope and contract conditions. Task 2 is Recommend and assisting in pre-qualification criteria and tender scoring and prepare the required score sheets while recommending on qualified designers after necessary profile review. The second function is recommendation for design competition is limited to one task by providing a recommendation for proposed designs.

Q.8. How do you describe project management consultants' roles and responsibilities at design stage of project's life cycle?

There were different responses to this question. The two areas of discrepancy came from the background of corporate business. As aforementioned in question No. 1, some of the PMC companies used to practice another role before adding PMC as an added division in the corporate business. Hence, according to findings of questions 1, one of the companies had an additional role of cost consultancy indifference to all other interviewees. Moreover one company advised that they were doing a comprehensive technical review of the developed design of the consultant. The results, therefore, suggest a lack of coherence regarding what the role of a PMC comprises of.

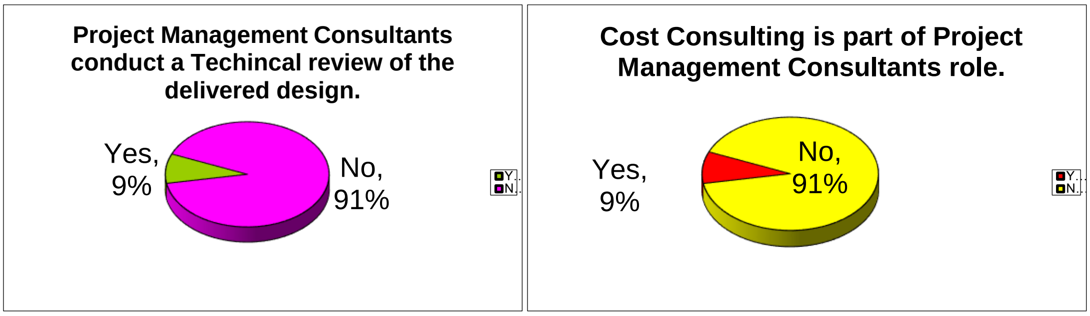


Figure 5.7: PMC conduct of technical review of the delivered design

All companies advised that they are managing the process of design production in order to ensure that it is delivered on time. However except for one case, all interviewed PMCs confirmed that they are not doing a technical review of the delivered design while they take holistic review against client requirements as well conducting the regular risk management meetings. The fact that PMC's are more focused on ensuring the client's requirements are met rather than if the design is technically sound is in line with previously discovered literary evidence where it was highlighted that the role of project management consultants is *"ensure that a client's needs, designs, specifications, and relevant information are made available"* (Chartered Institute of Building, 2002, p. 95).

In a continuation of exploring project management consultant's role; all interviewees agreed to the commercial involvement by managing payment process and variation. Moreover,PMCs role extended to manage the tender process for contractors appointing by organising tender documents, control and manage queries and its responses, prepare and manage the technical recommendation…etc.

Furthermore, there is an agreement that the PMC would manage the master program and phasing strategy as part of high-level planning.

The findings for this stage could be translated to the following description of the three main functions and its subsidiary tasks: Design Management, Commercial Management & Program Management. In each of these functions, there are several specific subsidiary tasks for PMC.

- . For design management, there are three subsidiary tasks.
    - Task 1 is Design Progress Management. This is implemented by continuously monitoring and controlling the progress of design development by the designer in line with agreed timeframe and program of works.
    - Task 2 is Design Drawing review against client requirements, design gaps and design clashes. It important to note that the review exercise is limited to general review (not in depth) for the produced design as the PMC does not carry out a technical liability. Therefore, this task usually limited to 1 architect or a very limited team of architects.
    - Task 3 is Risk Management, and this occurs by conducting regular risk register workshops where key risks are highlighted and necessary recommendation provided to the client.

The second function is Commercial Management which is divided into two tasks.

- Task 1 is to Manage Payments, and Cash flow for the design works by reviewing payments and commenting on variation if there is any against design contract and scope.
- Task 2 is to manage tender process for construction works by ensuring that tender documents are complete and in compliance with requirements and manage the process of technical evaluation as well commercial evaluation and finally recommend the best bidder.

As for Function 3, it involves high-level program management in light of the master program, packaging and phasing strategies, as well a review of program part in the submitted tender documents.

Q.9. What are the role of project management consultant at execution stage?

It was found that the construction stage was the one with the largest involvement by the PMCs within a project's lifecycle. Interview discussion at this stage consumed significantly longer duration than any other stage. The evidence of a larger role played by the PMC during the construction stages aligns with the findings of the literature review where it was advised by Kwakye (1997) and Spinner (1998) that one of the key advantages of PMC is to release architect from management role which could be claimed as management is not their best skill (Kwakye, 1997) and (Spinner, 1998).

As for roles and responsibilities; there was common agreement among the interviewees that PMCs administer and manage design related issues to clashes or changes. The importance of this role could be linked to the literature findings of this study where it was argued by Wilkinson (2001) that PMC offers non-vested interest advice and reduced in-house conflicts and disputes (Wilkinson, 2001).

Moving on with the discussion there was a common agreement by all interviewees for PMC involvement in managing the progress of construction as well as performing program management. This is again related to the previous finding in the literature review in this research as PMC would be 'good' in project time saving (Walker, 1998). To start with, typically the PMC would be pushing the contractor's progress and ensuring that delivering the project happens on time. Such role includes management and controlling engineering works (shop drawings and submittals) as well as procurement of materials mainly the long-lead items. Moreover, there were more duties of managing logistics by leasing with relevant stakeholders which agree with literature finding earlier in this research when it was found that PMC is *"a client advisor who leads, coordinates, supervises, and manages all the organizations in the project in order to achieve the project's objectives"* (Kerzner, 2001; Meredith and Mantel, 2000; Bennett, 1983). The common feedback by interviewees regarding safety and quality management was minimal involvement by PMCs as the liability for such roles remains with the Contractor and Supervision Consultant. However; in some projects, a representative from PMC would be involved in these roles as a recommendation party who conduct administration role as well.

Pertaining to commercial management similar to the design stage, it involves managing payments for both the consultant and contractor, managing variations, if any etc.

Findings of this question can be summarised as below:

The construction stage has five main functions: design management, progress and program management, commercial/contracts management, safety management and quality management. These functions have been developed by summarizing the findings from the interviews which related to the question ‘What are the roles of project management consultant at execution stage?’

- For the first function of design management it is limited to one task at this stage which is to Manage and resolve design clashes and gaps when they arise.
- For the second function is Progress and Program Management which is considered by many as the core function for PMC and it consists of 6 tasks:
    - Task 1 is Construction Progress Management which occurs by implementing monitoring and controlling tools for tracking and managing the progress on site and for conducting necessary action to ensure compliance with the program of works.
    - Task 2 is Program Management which is mainly about implementing project controls, systems and planning tools.
    - Task 3 is Procurement Management which includes implementation of monitoring and controlling tools for tracking and controlling procurements by the Contractor to ensure delivery on time and prevent delays to progress.
    - Task 4 is Engineering Management by implementing, monitoring, and controlling tools in order to ensure a smooth process and on track production of engineering works by the contractor. It is important to note here that PMC role is limited to managing the process only as they are not conducting the technical review. However, the PMC would provide a necessary recommendation based on the experience of their staff.
    - Task 5 is Logistics Management by conducting high-level coordination with various stakeholders to ensure proper logistics management process.
    - Finally, Task 6 is Risk Management, and this occurs by conducting regular risk register workshops where key risks are highlighted and necessary recommendations are provided to the client. The third function is commercial management. This function again is implemented by conducting two tasks.
        - Task 1 is Payment/Cash Flow Management by reviewing and authorising the payments released to supervision consultant and contractor.
        - Task 2 is Change Management by evaluating recommend for any claims raised by any party.
- The next function is Safety Management which was agreed by all interviewees that the presence of a safety representative by PMC is limited to providing recommendations only

for the overall management of contractor safety programs while such liability remains with consultant and contractor.

- Finally, Quality Management function which is also limited to recommendation only as the presence of Quality representative is not waving the liability of consultant and contractor.

Q.10. Should project management consultants be involved during the project handover stage?

The last stage of this interview was discussing project management consultants' roles and responsibilities at handing over the stage. The outcome of this discussion was an agreement by all interviewees. According to the discussions on this question, there is minimal involvement by PMCs during this stage. In line with their managerial role, PMC would typically manage and control the closeout stage of the project by administering the handing over documents, inspections, training, etc. In parallel to that, PMCs should manage final payments for both consultants and contractors.

Roles and responsibilities of this stage could be reflected as two key functions: the handing-over management and contracts & commercial management. For the first function, it is limited to one task of managing the closeout process and closeout documents by all parties. For the second function, it is limited to one task of managing claims and closeout payments.

There is one factual note which was emphasised by all interviewees related to all functions and tasks at all stages which are that the PMC role is advisory and the PMC do not hold any technical liability and their decisions are not compulsory.

The responses from these interviews were analysed through content analysis. Through the content analysis method, colour coding was used to highlight the key roles of PMC as provided by the interviewees at each of the three stages. The key roles and responsibilities emerging from the responses were summarised and are demonstrated in figure 5.8 below.

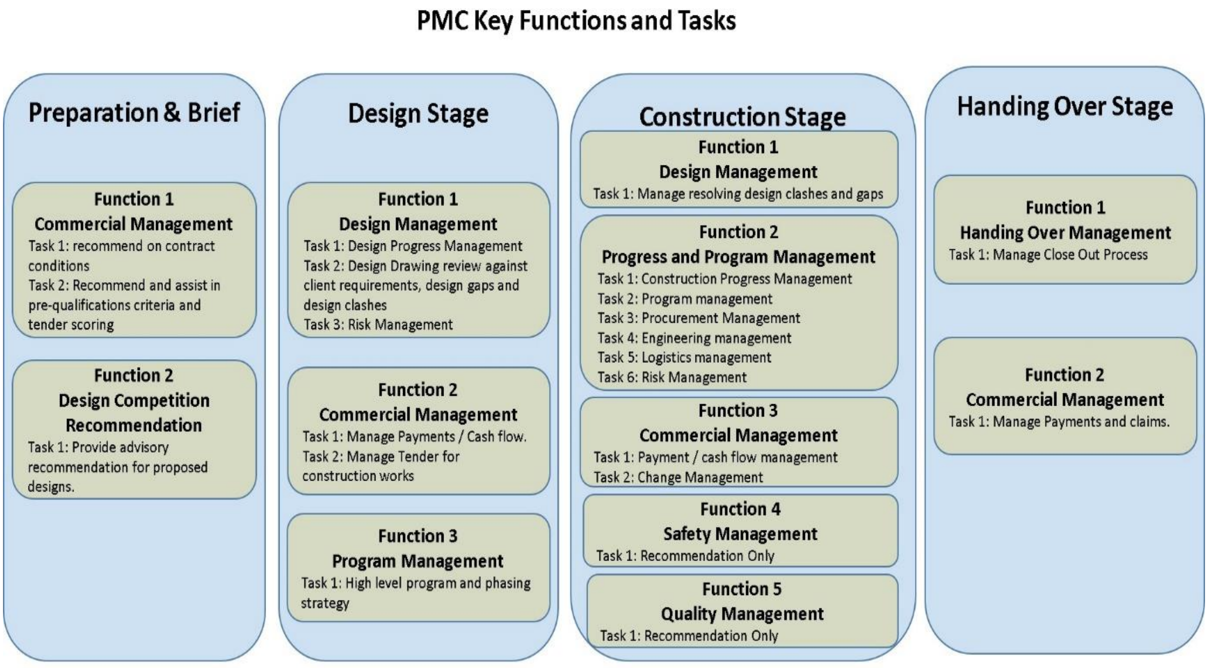


Figure 5.8. PMC Functions and Tasks for each stage of construction project

5.4.3 Overlay to RIBA plan of work

There are several process lifecycle management frameworks that are used which influence the role of the PMC. For example, APM has 6 broad stages of a project including concept, definition, development, handover, benefits realization, and operations management. APM provides three types of lifecycle frameworks: linear, spiral, and v-shaped, with each its own purpose and benefit (*Project management life cycle | Association for Project Management*, n.d.). On the other hand, the PMI lifecycle consists of initiation, planning, executing, controlling and closing (Duncan, 1993). While these can have a greater influence on PMC role in comparison to RIBA, RIBA is the only one which has a published overlay with BIM. Moreover RIBA Plan of work breaks down the project lifecycle into 8 stages which allows more flexibility of selecting relevant stages of project lifecycle inline of previous findings from interviews describing PMCs in UAE perspective for construction project stages in UAE. Finally; RIBA plan of work stages have the most similarity to the Digital Plan of Work as published by NBS which breaks down project stages to similar stages of RIBA plan of work *"https://www.thenbs.com/knowledge/what-is-the-digital-plan-of-work"* which comes in line with lifecycle of a digital project as defined in UK's BIM Standards PAS 1192-2013 as reflected in the figure below.

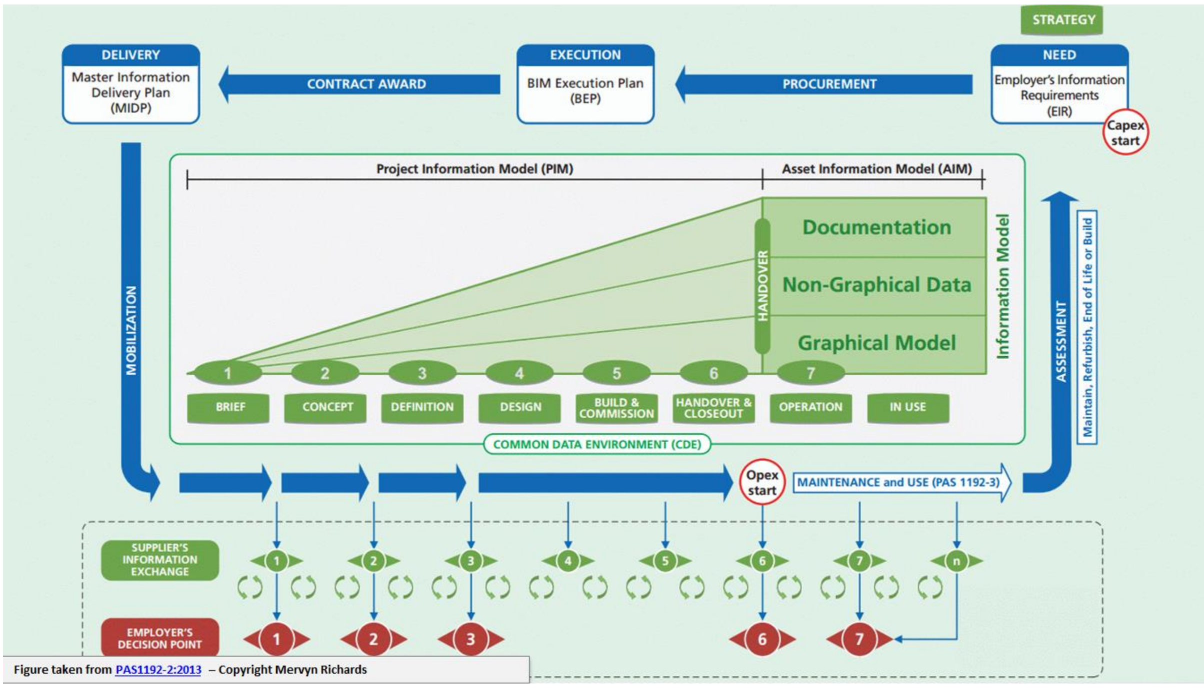
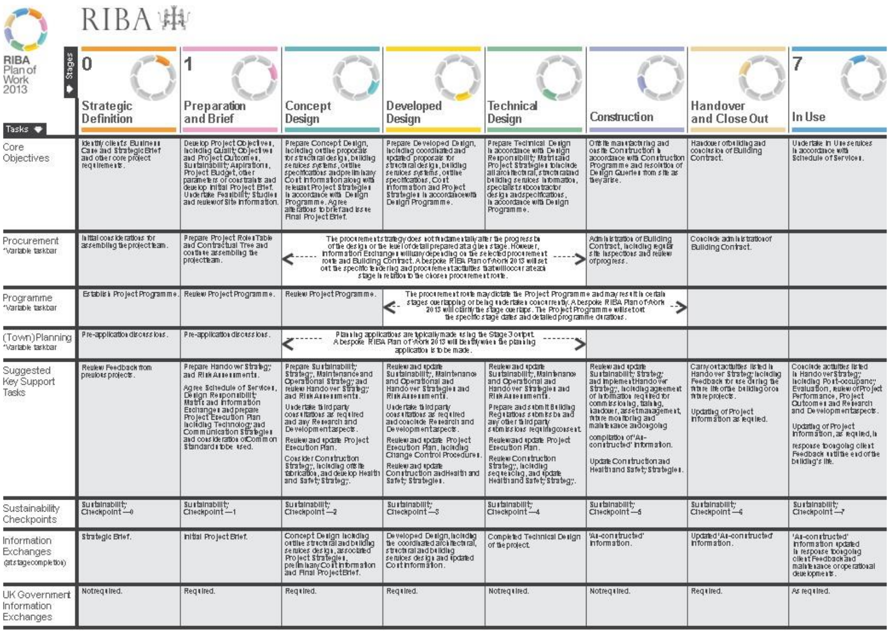


Figure 5.9: PAS1192-2:2013, The digital project lifecycle

In the RIBA plan of work the lifecycle of a project is broken down into 8 stages starting from strategic definition up to in use stage of the project. However, the reflected tasks in the below figure are variable tasks.



RIBA Plan of Work 2013

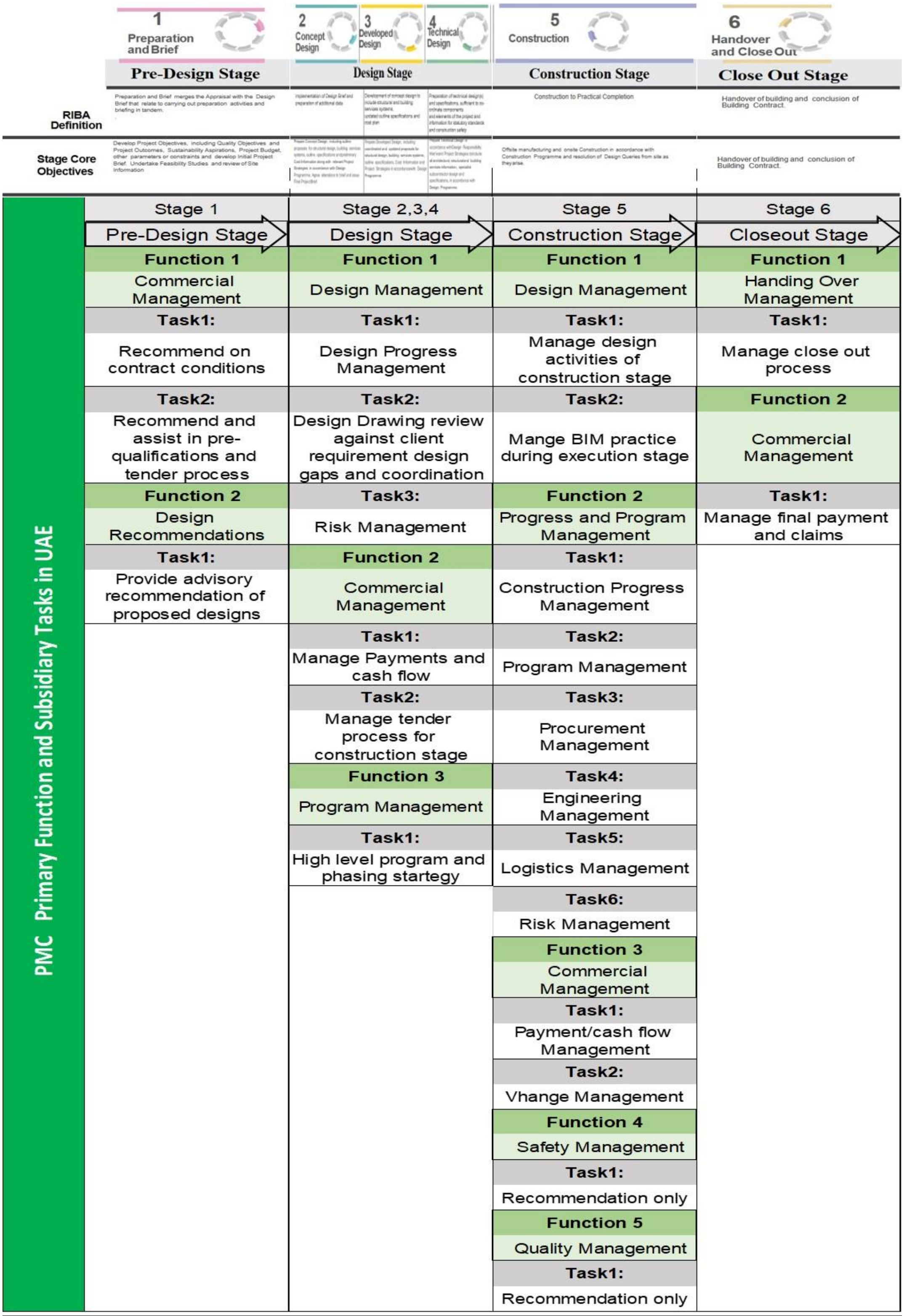
Tasks / Stages	0 Strategic Definition	1 Preparation and Brief	Concept Design	Developed Design	Technical Design	Construction	Handover and Close Out	7 In Use
Core Objectives	Identify client's Business Case and Strategic Brief and other core project requirements.	Develop Project Objectives, including Quality Objectives and Project Outcomes, Sustainability Aspirations, Project Budget, other parameters or constraints and develop Initial Project Brief. Undertake Feasibility Studies and review of Site Information.	Prepare Concept Design, including outline proposals for structural design, building services systems, outline specifications and preliminary Cost Information along with relevant Project Strategies in accordance with Design Programme. Agree alterations to brief and issue Final Project Brief.	Prepare Developed Design, including coordinated and updated proposals for structural design, building services systems, outline specifications, Cost Information and Project Strategies in accordance with Design Programme.	Prepare Technical Design in accordance with Design Responsibility Matrix and Project Strategies to include all architectural, structural and building services information, specialist subcontractor design and specifications, in accordance with Design Programme.	Offsite manufacturing and onsite Construction in accordance with Construction Programme and resolution of Design Queries from site as they arise.	Handover of building and conclusion of Building Contract.	Undertake In Use services in accordance with Schedule of Services.
Procurement *Variable task bar	Initial considerations for assembling the project team.	Prepare Project Roles Table and Contractual Tree and continue assembling the project team.	The procurement strategy does not fundamentally alter the progression of the design or the level of detail prepared at a given stage. However, Information Exchanges will vary depending on the selected procurement route and Building Contract. A bespoke RIBA Plan of Work 2013 will set out the specific tendering and procurement activities that will occur at each stage in relation to the chosen procurement route.			Administration of Building Contract, including regular site inspections and review of progress.	Conclude administration of Building Contract.	
Programme *Variable task bar	Establish Project Programme.	Review Project Programme.	Review Project Programme.	The procurement route may dictate the Project Programme and may result in certain stages overlapping or being undertaken concurrently. A bespoke RIBA Plan of Work 2013 will clarify the stage overlaps. The Project Programme will set out the specific stage dates and detailed programme durations.				
(Town) Planning *Variable task bar	Pre-application discussions.	Pre-application discussions.	Planning applications are typically made using the Stage 3 output. A bespoke RIBA Plan of Work 2013 will identify when the planning application is to be made.					
Suggested Key Support Tasks	Review Feedback from previous projects.	Prepare Handover Strategy and Risk Assessments. Agree Schedule of Services, Design Responsibility Matrix and Information Exchanges and prepare Project Execution Plan including Technology and Communication Strategies and consideration of Common Standards to be used.	Prepare Sustainability Strategy, Maintenance and Operational Strategy and review Handover Strategy and Risk Assessments. Undertake third party consultations as required and any Research and Development aspects. Review and update Project Execution Plan. Consider Construction Strategy, including offsite fabrication, and develop Health and Safety Strategy.	Review and update Sustainability, Maintenance and Operational and Handover Strategies and Risk Assessments. Undertake third party consultations as required and conclude Research and Development aspects. Review and update Project Execution Plan, including Change Control Procedures. Review and update Construction and Health and Safety Strategies.	Review and update Sustainability, Maintenance and Operational and Handover Strategies and Risk Assessments. Prepare and submit Building Regulations submission and any other third party submissions requiring consent. Review and update Project Execution Plan. Review Construction Strategy, including sequencing, and update Health and Safety Strategy.	Review and update Sustainability Strategy and implement Handover Strategy, including agreement of information required for commissioning, training, handover, asset management, future monitoring and maintenance and ongoing compilation of 'As-constructed' Information. Update Construction and Health and Safety Strategies.	Carry out activities listed in Handover Strategy including Feedback for use during the future life of the building or on future projects. Updating of Project Information as required.	Conclude activities listed in Handover Strategy including Post-occupancy Evaluation, review of Project Performance, Project Outcomes and Research and Development aspects. Updating of Project Information, as required, in response to ongoing client Feedback until the end of the building's life.
Sustainability Checkpoints	Sustainability Checkpoint — 0	Sustainability Checkpoint — 1	Sustainability Checkpoint — 2	Sustainability Checkpoint — 3	Sustainability Checkpoint — 4	Sustainability Checkpoint — 5	Sustainability Checkpoint — 6	Sustainability Checkpoint — 7
Information Exchanges (at stage completion)	Strategic Brief.	Initial Project Brief.	Concept Design including outline structural and building services design, associated Project Strategies, preliminary Cost Information and Final Project Brief.	Developed Design, including the coordinated architectural, structural and building services design and updated Cost Information.	Completed Technical Design of the project.	'As-constructed' Information.	Updated 'As-constructed' Information.	'As-constructed' Information updated in response to ongoing client Feedback and maintenance or operational developments.
UK Government Information Exchanges	Not required.	Required.	Required.	Required.	Not required.	Not required.	Required.	As required.

Figure 5.10 RIBA Plan Of Work. Source *www.ribaplanofwork.com*

From the conducted interviews, it was noticed there are variances in stages' descriptions as the three stages of concept design, developed design, and technical design are all laying under the design stage where PMC role is similar in the three stages. Moreover, it was noticed that there is no involvement from PMC for strategic definition and in use stages. Those changes in the stages been taken into consideration while overlaying the collected data on the RIBA plan of work.

The following Figure 5.11 summaries the outcomes of this chapter as it reflects interviews outcome for the current role and practice for PMC in UAE and how it is overplayed to RIBA Plan of Work.

As a result of the interviews, the respondents provided a detailed account of the ideal tasks that the PMC should be involved in to ensure a time and cost efficient process. These processes have implications with the RIBA plan of work overlayed to BIM. The below figure depicts some of the similarities between the RIBA plan of work overlay to BIM and the new framework developed as a result of this study. In addition, as mentioned above, while there are similarities, the tasks that are carried out in each of the RIBA stages are variable and some stages have similarities with one another. Hence, the below figure shows a consolidate framework for the same.



5.11. Overlay of PMC Role in UAE over RIBA plan of work

5.5 Interview B

This interview involved posing questions pertaining to the current limitations and gaps in BIM practice and thereby investigating the recommendations for optimum utilisation of BIM within PMC team in the project. The findings of this part would shape the elementary bases for drafting the proposed scenario for a framework which will be tested through case studies. In order to accomplish the anticipated valuable responses, the selection has been carefully of the potential interviewees. The targeted personnel were selected to be BIM representatives within PMC organisations, Design organisations and contractors. The outcome of these interviews will support in drafting the proposal for the framework in the following stage of this research.

5.5.1 Interview B questions design

The following part will explain the designed questions and explanation for the purpose of the question and how it will be valuable for this research.

Q.1. Do you believe that involving PMC in the BIM process would add value to <u>the project</u>?

Q.2. Do you believe that involving PMC in the BIM process would add value to <u>the PMC team</u> and their role?

Q.3. In your opinion what would be a new role for PMC pertaining BIM at each stage within the project life cycle?

The above three questions are interlinked with one another and are investigating suggestions for new core functions which potentially could be added to the roles and responsibilities of PMCs at each stage of the projects' life cycle.

Q.4. In your opinion; how should BIM integrate into current functions and tasks of the pre-design stage?

Q.5. In your opinion; how should BIM integrate to current functions and tasks of the design stage?

Q.6. In your opinion; how should BIM integrate to current functions and tasks of the construction stage?

Q.7. In your opinion; how should BIM integrate to current functions and tasks of handing over stage?

Questions 4 through 7 provide the answers which directly influence the development of the framework. Every function and the resultant subsidiary task were discussed with each interviewee at length.

5.5.2 Interview B responses and analysis

The value of each research comes from its outcomes. Therefore, the following part is a reflection of concluded outcomes from these semi-structured interviews. The interviewed persons were:

- 5 BIM Managers selected from PMC Organizations
- 2 BIM Managers from Design Consultancy firms
- 2 BIM Managers from Contractors firms.

The purpose behind choosing a wide array of BIM Managers across various firms was to gain a diverse perspective on the ideal PMC tasks in coordination with the BIM overlay of RIBA.

The interview involved discussion of current produced framework and new functions, tasks or amendments to the current framework. Since every BIM Manager had a different perspective on the functions of the PMC at various BIM stages, this approach allowed for the consideration of those varied perspectives. Finally, these were analyzed with respect to the BIM Overlay of RIBA which helped in the development of the framework prototype. This framework was then validated using ten interviews.

Pre-Design Stage:

The previous outcome from Interview A included two functions of Commercial Management and recommendation on a design competition. All interviewees agreed that there should be a new function added to the current function pertaining to BIM.

There was a common agreement between the suggestions of the respondents that they need to "Identify and draft Project's BIM strategy" which would be essential for project success, as currently there is a severe gap in the industry for a proper Employers Information Requirements (EIR) and clear project's BIM requirements identifying deliverables, by whom it is delivered, when and how.

It is believed by all parties that PMC would be the ideal party to draft such requirements in accordance with the clients' expectations along with EIR, which commonly covers the operational requirements, but does not focus on the process management during design and execution. During the interview, it was also emphasised by almost all the participants that the development of EIR from should take the form of an iterative process. Specifically, it was recommended that a simple information requirements process map should be used at the initial stage to identify key decisions to be made during the project. This will ensure that the identified solutions contribute directly towards meeting business needs.

According to the respondents, the EIR should also include all key materials, functional and performance information in relation to floors, spaces and facilities. The respondents also stated that when the design has progressed, the team can propose more specific requirements for EIR use in activities such as procurement. Some of the main EIR components identified by the interviewees include information-related roles and responsibilities, standard procedures and methods from which the information is to be created and exchanged, the information delivery plan as well as the COBie demand matrix.

The drafting of the requirements would be achieved by reviewing the client BIM requirements through EIR as well as providing necessary recommendations to the same. It is recommended that the client would focus on their requirements on the end result rather than the process. It was also agreed among the interviewees that in most of the technical aspects of BIM, the clients should be guided on the nature of their contributions since most employers tend to be inexperienced in terms of setting out detailed or high-level requirements. The client in such a case, should only be required to provide requirements in the form of basic rules that the PMC can further develop or review. This would, for example, involve engaging in small group exercises with the client in order to offer relevant background information from which the requirements can be based on. The consultants should then proceed with the technicalities involved in implementing the requirements.

The interviewees noted that there is also a need to add necessary requirements from a project delivery perspective. This could be identified as a new addition of Function 3 with two subsidiary tasks. Therefore, from the above discussion of the interview results, the following summary can be developed:

- Task 1 is a review of EIR and making the necessary comments and recommendations towards best practice.
- Task 2 is drafting the project BIM requirements which cover the entire process from initiation of EIR up to handing over to Operations including management process identifying each stakeholders' involvement in the BIM process. In order to effectively achieve Task 2, the interviewees reinforced the importance of an early understanding of the client's/employer's requirement and expectations. Once such an understanding is achieved it becomes possible to during the BIM requirements drafting process to include procedures and processes that best suit both the client and project.

In addition to the newly added function, there were several amendments suggested by the interviewees to the current functions. The current function of Commercial Management involves contribution by the PMC drafting the scope of the designer. The additional task to the current function involves PMC drafting the BIM clauses and section in the designer scope to be in line with overall project BIM requirements. The involvement of PMC in this stage was also considered to be important since the consultant is able to provide an impartial view of the designer's work. The consultant drafting the BIM clauses should participate in all three key phases of the design contract which include the schematic design, design development and construction drawing phases. During the drafting of the scope, the designer should take into consideration the use of BIM in the development of program requirement from which the designer can develop drawings of key aspects such as the preliminary site plan, elevation and building sections in the schematic design phase. During the design development phase, PMC could be involved in ensuring that comments from the owner are incorporated using the help of BIM in the structure, mechanical and electrical requirements of the project. Lastly, on the construction drawing phase, the role of PMC in drafting the designer scope and BIM clauses revolves around ensuring that the designer uses complete and accurate specifications in the final design drawing.

In addition, the currently collected data demonstrates that PMC involves reviewing the prequalification of designers. Hence, an additional task would involve PMC to review the BIM maturity of the designers and evaluate their BIM capabilities among other criteria, making necessary recommendations towards BIM capabilities. While further expounding on this task, the interviewees noted that PMC should go beyond the traditional prequalification process which tends to place too much emphasis on price at the expense of other important attributes such as quality and experience. In accordance, the prequalification of contractors should be based on their ability to use BIM to provide great overall value to the project. It also means that BIM capabilities should be prioritised in terms of the possession of the requisite level of experience, technical BIM competence and the ability to work cooperatively which is a key aspect of the BIM process. One of the interviewees suggested that PMC should require interested designers to make responses to a detailed BIM questionnaire. Additional information pertaining to BIM capabilities could be obtained from personal interviews. The information collected should be used to rank the designers and only the prequalified ones invited to submit proposals.

The interviewees also recommended a review of the tender documents. PMC is conducting the necessary technical review of the submitted proposals by the designer. The same would be applicable for BIM sections within the submitted documentation. According to one of the interviewees, design reviews are necessary to identify the designers' capabilities in adapting BIM in their scope which will affect the overall produced design as it is essential for the success of BIM practice in the project. With regard to the implementation of the tender document review, the interviewees explained that PMC during the tender review process should be keen on establishing the level of BIM data integration. The documents should also highlight the specific BIM standards agreed for use in the project scope, the relevant schema for integration, and approaches to adopting various project applications to the BIM standards. In other words, the bidders should be able to demonstrate that they are capable of efficiently adapting BIM into their scope of work.

Design Stage:

At this stage, the interviewees had been informed of current practice functions, and tasks by PMC as the outcome from interview A. The current functions included Design Management, Program Management & Commercial Management.

Similar to the pre-design stage and as mentioned earlier, the respondents recommended adding a new function which would be an addition to the roles and responsibilities of PMC: BIM management. Thus, in keeping with the responses, tt the design stage, the BIM management function will be comprised of three subsidiary tasks.

Task 1

Task 1 involves review, comment and approval of designers BIM execution plan. According to interviewees, this task would ensure that designers plan to author the BIM model and to manage is in accordance with the overall project BIM strategy and objectives which were set by the PMC at the pre-design stage. This is essential for controlling the BIM model development and the overall management process. As part of Task 1 on approval of designers, the PMC should consider several important aspects as suggested by the respondents:

1. PMC should check out on design authoring, cost estimation and design coordination.
2. PMC team should evaluate the extent to which the presented BIM execution plan is capable of providing for a reliable establishment for developing, usage, transmission and exchanging of digital data. The plan should also define the various expectations for development of model elements at each of the project milestones.

The interviewees also emphasised the importance of reviewing the BIM responsibilities as indicated in the execution plan. The PMC should, as per the interviewees, be on the lookout for whether there are design team members assigned with the responsibility of managing BIM updates such as revising of BIM to reflect design changes that may be initiated by various stakeholders such as the project owner.

Task 2

Based on the interview responses, Task 2 compromises of monitoring and controlling the BIM model development process. After setting the BIM Execution Plan by designer and getting it approved by the PMC, it is essential to monitor and control the deliverables. The same is achievable by conducting necessary regular meetings where PMC would have control over the developed BIM model. Moreover, the model development control is achieved by reviewing the developed model at each stage of design development.

It is argued by 40% of the interviewees that PMC should technically verify the components of the model in line with standards and project objectives and strategy. However, it is argued by 60% of interviewees that the technical parts of the model are the solely the liability of the designer as they believe that PMC would conduct a general review against main client design requirements. The 60% of the participants emphasized the need for ensuring the client is satisfied.

Task 3

Task 3 under BIM management function at design stage comprises of BIM commercial management. This task involves the PMC in drafting the relevant BIM clauses in the contracts for contractors as well as conducting the necessary review of BIM section of the tender documents. This task would be interrelated to the commercial management function by PMC at the design stage. As explained by the interviewees, this means that the PMC should perform an important role in terms of reviewing and authorisation of important BIM commercial management practices such as cost planning and estimation, budgeting/cash flow, sourcing and sub-contracting and contract administration. An extension of this task entails evaluating claims raised by the other parties in relation to the commercial aspects of BIM and making recommendations for changes.

Construction Stage

The construction stage traditionally included five functions by PMC. However, 100% of the interviewees agreed that a new function of BIM management must arise as well. The new function of BIM management again will include several subsidiary tasks as follows. All of these subsidiary tasks that have been outlined have been developed based on the responses of the participants of the interview.

Task 1

Reviewing, commenting on and approving the BIM execution plan by the contractor are important aspects of the BIM Management function. It was agreed by all interviewees that similar to the design stage, this task will ensure that the development and uses of BIM at construction stage will be in-line with project overall BIM strategy and objectives. The review of the BIM execution plan by the contractor also includes PMC assessing the extent to which construction team responsibilities in relation to BIM have been correctly articulated. Some of the interviewees, for instance, explained that the execution plan should explain that the construction team will main maintain and record original drawings in order to facilitate review and comparison of any changes and deviation to the BIM during the construction process. The execution plan should also explain that the construction team will ensure that all updates received regularly from the design team will be incorporated into the BIM. It is also the responsibility of the construction team to ensure that the BIMs and original As-Built Field Data is provided to the design team for final preparations.

Task 2

The second task under BIM management Function will be managing BIM practice during construction stage. Similar to the design stage, this task would be conducted regularly during the execution stage of projects lifecycle which will ensure that BIM is being used at best as designated to serve project needs and to gain maximum benefits in line with Project BIM strategy and requirements as well ensure it is serving other tasks related to the project such as time management.

In greater detail, the interviewees explained the need for PMC to use BIM to assess whether design models may have been replaced with models from the sub-contractors. The main aim, in this case, is to ensure that the design intent is followed. In addition, PMC performs an important role in BIM management in the construction stage by running clash detections on all models. The identified problems can be cross-checked with records from BIM with the ultimate goal of ensuring that discrepancies can be resolved during the construction process.

Construction Phase Task 3

The third task at the construction stage is the coordination management. It is expected that PMC would take a leading role in coordination between project stakeholders whether internally or externally. Such task comes in line with the previous finding of chapter 2 of this research where it was advised that the role of project management consultants is *"ensure that a client's needs, designs, specifications, and relevant information are made available"* (Chartered Institute of Building, 2002, p. 95). PMC should in this context assess whether various parties to the project such as designers and contractors are not only coordinating but also making effective use of BIM in order to ensure a faster a more efficient project process. As further explained by one of the interview PMC performs an important role of the dedicated model coordinator. This role requires PMC to regularly take the multidisciplinary project team through coordination sessions where model inconsistencies and clashes are identified, and parties agree on how to obtain solutions.

This BIM role deviates significantly from the traditional documentation coordination process that required the coordinator to make use of 2D document printouts.

Handing Over Stage

Managing handing over process of BIM deliverables against project requirements and in coordination with operations requirements is the task of the added BIM Management function. This PMC task as cited by some of the interviewees contributes significantly towards overcoming challenges encountered by facility managers in a non-BIM project. For example, it was indicated that it is common for facilities managers in a non-BIM project to rely on manually formatted data which is difficult to locate accurate information about the building. By ensuring that the facility manager receives building and maintenance data in an agreed BIM format, PMC helps reduce the unnecessary, time-consuming efforts in locating and updating the building's information.

5.6. Chapter conclusion

This chapter provided an overview of the data collection process, the interviews developed and presented to the interviewees, the analysis of the responses as well as a brief discussion on the analysis. 11 questions in part one interviews were asked to identify the role of PMC as it currently exists. Only those individuals who, through their work, can have a comprehensive understanding of the construction industry in the UAE and of the role of PMC were interviewed. The responses obtained thereafter were analysed and the trends graphically represented. In the next round of interviews, seven questions were asked which allowed the interviewees to provide detailed information about the ideal roles of PMC and what it can do to their projects. These results form the basis of the framework development and of the validation process.

Chapter 6

Prototype Framework and Interview Validations

6.1 Introduction

The previous parts of this research covered the literature review and data collection interviews. The data collection included investigating current PMC roles and responsibilities and the second interviews cover the recommendation from industry for Project management consultants' involvement in the BIM practice throughout different stages of the project lifecycle. This chapter proceeds to the next stage of the research. The chapter seeks to draft a chart of the proposed prototype for project management consultants' roles and responsibilities towards BIM at each stage of a project's lifecycle.

According to Maxwell (2005), a conceptual framework is defined as something that is constructed by the researcher using the ideas and theories from various sources during the research process. Maxwell has also outlined four sources of knowledge that the researcher can use to build the framework which include experiential knowledge, existing theory, exploratory research and thought experiments. In this research, existing theory is built upon by using the experiential knowledge of the industry experts (research participants) and exploratory research.

As discussed earlier in the preceding research methodology chapter modification and innovation are the main focus the research, and close coordination with the participant is crucial for the success of the research. Gittins (2007) suggested that researchers should examine their proposed solution in relation with industry organisations and practitioners. Accordingly, this chapter will also cover a case study which will aim to validate and testify to the finding of previous chapters and the produced framework.

6.2 Research process

From the review of literature in the preceding chapters, one of the issues that arise is that PMC role in relation to use of BIM in the construction process is yet to be clearly defined. The review also indicated that there is a general consensus among researchers and practitioners that the use of BIM in construction projects provides significant benefits in all measures of project success. Given that PMC acts as the client representative it is expected that the project management consultants should play an important role in terms of management of BIM on behalf of the client. Ideally, the PMC roles in BIM management should start at the early stages of the project since BIM is designed to support the project right from its inception. It is for this reason that the present research sought to investigate the PMC roles in BIM management from the pre-design stage of the project lifecycle to the close out stage. While doing so, it is important to evaluate the extent to which the identified tasks are considered relevant or valid by practitioners. It is on this basis that the framework prototype is validated through the use of ten interviews.

Validation as a process has a number of benefits as have been outlined below (Murray-Smith, 2015):

- Firstly, it helps to establish the strength of the findings. Stronger findings are likely to be more valid and applicable to real settings.
- Second, validation helps establish a level of consistency and coherence in the research findings. In other words, validation helps ensure that the proposed ideas link up well and that there are no unnecessary duplications, redundant findings and information that conflicts with current practices and existing knowledge.
- Third, validation helps increase the specificity of the findings (Ghauri, 2004; Murray-Smith, 2015). In this case, it becomes possible to establish the extent to which the findings are necessary and sufficient. These benefits are derived since validation depends on the opinions, knowledge and experience of individuals who have expertise in the real system which in the context of the present research is project management consultancy.

Before the validation can be carried out, the first draft of the framework needs to be developed. The framework was developed based on the analysis of the interviews conducted in the first half of this study. The analysis of the interviews was done in the following manner. First, the existing process of the projects lifecycle was identified and studied. For this, the RIBA plan of work overlayed to BIM was studied and analysed. This allowed the development of the skeleton on which the proposed framework was based on. The next step was to discuss the developed framework that was designed as an initial step with industry experts who have been purposively chosen to represent the views of the industry. In addition, this was also essential to validate the framework and gain an in-depth experts opinion on the same. The analysis of the responses was carried out in a systematic manner. First, the interviews were transcribed and similar themes were identified, Next, the similar themes were color coded and arranged based on which task is stated where. Each of the interview responses were developed into draft frameworks and their information flow was developed in addition to which tasks had implications over which stage. All of the drafts were compared and contrasted. Similar ones were grouped together. In cases which differed, the focus was turned towards the majority views and those were accepted. This was carried out until the final framework was reached, validated and approved. This was the method of analysis of the interviews applied and hence, the final framework was developed. The following sections provide the analysis in a stepwise manner. The RIBA Plan of work with overlay to BIM is discussed first, then the responses and are provided based on the groups that were interviewed. The grouping has been done in such a way where the similar responses have been grouped together and presented. Finally, at the final stage, the similarities and the additions were added together and the final framework is presented.

6.3 Framework Prototype

The first step was to comprehend and analyse the framework of the existing practice for PMC in a project's lifecycle. Once this was sufficiently understood, a new framework was developed. The primary purpose of this section is to provide a basis for the development of the framework with the information that was received from the interviews. Gaining a clear picture and comprehension of what the current processes and procedures are will point the study in the right direction. Doing so will also add robustness to the study and hence, provide us with a solid framework that has been validated by industry experts. Hence, analyzing and describing the BIM Overlay to RIBA is part of an exploratory process whereby information gathering will be carried out to establish a strong base on which the new framework will be developed.

The BIM Overlay to the RIBA Plan of Work is divided into various work stages from A through M (RIBA, 2013). The First stage which is the Preparation Stage consists of Appraisal and Design Brief as sub stages A and B. Some of the key tasks of the Appraisal stage are client needs and objectives assessment, sustainability, and constraints if any on the development. Feasibility studies are developed here. The Design Brief stage B, on the other hand, consists of a statement of requirements, identification if key procurement methods, project sustainability, the organisational structure of consultants, and defining of the responsibilities.

	RIBA Work Stage		Description of Key Tasks	Core BIM Activities
Preparation	A	Appraisal	Identification of client's needs and objectives, business case, sustainability, life cycle and Facilities Management aspirations and possible constraints on development. Preparation of feasibility studies and assessment of options to enable the client to decide whether to proceed.	• Advise client on purpose of BIM including benefits and implications. Agree level and extent of BIM including 4D (time), 5D (cost) and 6D (FM) following software assessment. Advise client on Integrated Team scope of service in totality and for each designer including requirements for specialists and appointment of a BIM Model Manager. • Define long-term responsibilities, including ownership of model. • Define BIM Inputs and Outputs and scope of post-occupancy evaluation (Soft Landings). • Identify scope of and commission BIM surveys and investigation reports. • Data drop 1.
	B	Design Brief	Development of initial statement of requirements into the Design Brief by or on behalf of the client, confirming key requirements and constraints. Identification of procurement method, project sustainability and BIM procedures, building design lifetime and project organisational structure and range of consultants and others to be engaged for the project, including definition of responsibilities.	

Figure 6.1. BIM Overlay of RIBA Work Stage A and B (RIBA, 2013)

In terms of the core BIM activities, advising clients on the purposes of BIM, on the Integrated Team Scope, the definition of the long term responsibilities, inputs and outputs and identification of scope. Figure 6.1 provides an overview of work stages A and B.

The Design stage consists of Concept, Design Development, and Technical Design (C, D, and E) Work Stages. Concept stage consists of implementing design briefs and developing new data, developing outline proposals for structural and environmental services, site landscape and ecology, and review of procurement route, among others. Design Development stage consists of designing the concept using BIM data to incorporate environmental strategies along with structural ones, site landscape, and current outline specifications and initial cost and energy plans. The Technical Design stage includes the development of technical designs, coordination components, BIM data on the statutory standards, and sustainability assessments.

The BIM activities include sharing of data and design integration with data linkages between models, integration of design elements, environmental performance analysis, exportation of data to the planning application and finally, 4D/5D assessment.

Design	C	**Concept**	Implementation of Design Brief and preparation of additional data. Agreement of Project Quality Plan including BIM and Change Control protocols. Preparation of Concept Design including outline proposals for structural and environmental strategies and services systems, site landscape and ecology, outline specifications, preliminary cost and energy plans. Review of procurement route.	• BIM pre-start meeting. • Initial model sharing with Design Team for strategic analysis and options appraisal. • BIM data used for environmental performance and area analysis. • Identify key model elements (e.g. prefabricated component) and create concept level parametric objects for all major elements. • Enable design team access to BIM data. • Agree extent of performance specified work. • Data drop 2.
	D	**Design Development**	Development of concept design using project BIM data to include structural and environmental strategies and services systems, site landscape and ecology, updated outline specifications and cost and energy plans. Completion of Project Brief. *Application for detailed planning permission.*	• Data sharing and integration for design co-ordination and detailed analysis including data links between models. • Integration/development of generic/bespoke design components. • BIM data used for environmental performance and area analysis. • Data sharing for design co-ordination, technical analysis and addition of specification data. • Export data for Planning Application.
	E	**Technical Design**	Preparation of technical design(s) and specifications, sufficient to co-ordinate components and elements of the project, BIM data and *information for statutory standards,*	• 4D and/or 5D assessment. • Data drop 3.

Figure 6.2. The BIM Overlay of RIBA Work Stage C, D and E (RIBA, 2013).

For the Pre-construction stage, the Work Stages are Product Information (F), Tender Documentation (G), and Tender Action. F consists of developing the BIM data in order to create a coordinated design team with performance outlined work for facilitating the tender approval process. G consists of the development of the tender documentation to enable the tender to be obtained. H consists of evaluation and discovery of contractors or project specialists. Getting and assessing tenders are also included in this step.

The BIM activities include the data sharing and analysis, modelling, integration and analysis, parametric objects, final review of the model, integration of subcontractor model, review of construction sequence and final review and signing off of the model. This is depicted in figure 6.3.

Pre-Construction	F	Production Information	F1 ~~Preparation of production information~~ Development of BIM data in sufficient detail to conclude co-ordination of design team inputs, to enable performance specified work to commence and enable a tender or tenders to be obtained. *Application for statutory approvals.* F2 ~~*Preparation of further information for construction required under the building contract.*~~ *Development of BIM data to integrate performance specified design work into model.* Review of BIM information provided by contractors and specialists, including integration into project BIM data.	• Export data for Building Control Analysis. • Data sharing for conclusion of design co-ordination and detailed analysis with subcontractors. • Detailed modelling, integration and analysis. • Create production level parametric objects for all major elements (where appropriate and information exists this may be based on tier 2 supplier's information). • Embed specification to model. • Final review and sign off of model. • Enable access to BIM model to contractor(s). • Integration of subcontractor performance specified work model information into BIM model data. • Review construction sequencing (4D) with contractor. • Data drop 4.
	G	Tender Documentation	Preparation and/or collation of tender documentation in sufficient detail to enable a tender or tenders to be obtained for the project.	
	H	Tender Action	Identification and evaluation of potential contractors and/or specialists for the project. Obtaining and appraising tenders; submission of recommendations to the client.	

Figure 6.3. The BIM Overlay of RIBA Work Stage F, G and H (RIBA, 2013).

In the same way, figure 6.4 depicts that BIM overlay of work stages J, through M.

Construction	J	Mobilisation	Letting the building contract, appointing the contractor. ~~Issuing of information to the contractor.~~ Arranging site handover to the contractor.	• Agree timing and scope of 'Soft Landings'. • Co-ordinate and release of 'End of Construction' BIM record model data. • Use of 4D/5D BIM data for contract administration purposes. • Data drop 5.
	K	Construction to Practical Completion	Administration of the building contract to Practical Completion. ~~Provision to the contractor of further information as and when reasonably required.~~ Clarification and resolution of design queries as they arise. ~~Review of information provided by contractors and specialists.~~ Assist with preparation for commissioning, training, handover, future monitoring and maintenance.	
Use	L	Post Practical Completion	L1 Administration of the building contract after Practical Completion and making final inspections. L2 Assisting building user during initial occupation period.	• FM BIM model data issued as asset changes are made. • Study of parametric object information contained within BIM model data. • Data drop 6.
R&D	M	Model Maintenance & Development	L3 Review of project performance in use and comparison with BIM data. Analysis of BIM data for use on future projects, following feedback and research.	

Figure 6.4. The BIM Overlay of RIBA Work Stage J, K, L, and M (RIBA, 2013)

In light of the above BIM overlay of RIBA plan of work, the following is a draft for the suggested BIM related functions and tasks for the project management consultancy role and responsibilities in UAE. The additional function at each stage will be under the title of BIM Management. However, it is important to identify the tasks under this function at each stage of the project with proper descriptions. The following tasks have been developed with the use of interviews conducted in the first half of the study. The interviews were conducted with 11 experts and 9 BIM Managers. The tasks are an integration between the BIM Overlay of RIBA and the result from the interviews. Doing so has allowed the researcher to consider a wide range of functions and tasks at every stage and present an overall perspective on the functions.

The validation has been conducted in the following manner. The framework was drawn up by the researcher and presented to 10 participants (4 PMC, 2 Clients, 2 Contractors, 2 BIM Managers) in the validation interviews. The research process was explained to them and the framework was presented. The primary question that was asked to these groups of people was if they agreed to the framework and if not, what changes they recommend. Below is a brief account of what the task at each stage entails.

Framework Pre-Design Stage

At this stage, it is suggested that PMC will conduct two main tasks.

Task 1

Involves participating in the finalization of the overall BIM strategy throughout the project. This task includes a review of Employers Information Requirements (EIR), commenting on it and proposing any necessary amendments.

Task 2

Involves drafting BIM scope and requirements including standards for both consultant and contractor. This task also includes drafting the necessary contract amendments to contract clauses.

Task 3

Involves participating in review the BIM section in the pre-qualification documents for designers during competition for designer selection.

Framework Design Stage

At this stage and under the BIM management function, there are 4 tasks expected to be performed by PMC.

Task 1

Involves reviewing and managing the proposed BIM execution plan by the consultant in order to ensure compliance with EIR and general BIM requirements.

Task 2

Managing the process of BIM development in line with project requirements and program of works. This task is executed through leading regular BIM meetings.

Task 3

Participating in the tender process by reviewing the BIM section of bidders' documents and evaluating the BIM weight in bidders' technical proposals

Framework Construction Stage

At this stage, the contractor is already on board as well the supervision consultant. The expected tasks by PMC would be:

Task 1

Managing and leading BIM meetings with all relevant stakeholders as well as all BIM relevant uses.

Task 2

Review and comment on contractors BIM execution plan to ensure compliance with EIR and project general BIM objectives.

Task 3

Leading coordination between contractor and operator to ensure a proper handing over process.

Framework Handing Over Stage (Close Out)

This stage will involve one main task

Task 1: Manage handing over of BIM deliverables between various stakeholders.

The summary of the above-mentioned functions and tasks for each stage could be overlaid to RIBA plan of works as per the following figure 6.5.

	Project Stages As per RIBA Plan Of Work			
PMC New BIM Primary Function and Subsidiary Tasks	Stage 1	Stage 2,3,4	Stage 5	Stage 6
	Pre-Design Stage	Design Stage	Construction Stage	Closeout Stage
	New Function	**New Function**	**New Function**	**New Function**
	BIM Management	BIM Management	BIM Management	BIM Management
	Task1:	**Task1:**	**Task1:**	**Task1:**
	Review edit & comment EIR and Draft project BIM strategy	Review / Approve designers BXP	Review / Approve contractor's BXP	Manage the process of handing over BIM deliverables
	Task2:	**Task2:**	**Task2:**	
	Draft BIM scope for designer and contractor	Mange BIM development process by the design team	Mange BIM practice during execution stage	
	Task3:	**Task3:**	**Task3:**	
	Review BIM section in designers pre-qualifications	Manage BIM related parts of contractors tender process	mange coordination between internal / external stakeholders	

Figure 6.5 PMC BIM functions and task overlaid to RIBA plan of work as result of interviews B

6.4 Data Analysis and Sample Size

For the process of validation, a group of ten participants were selected. The selection criteria was very important and essential in order to ensure best outcome suites the qualitative enquiry of the research. The selection criteria was the following:

- Has appropriate knowledge of BIM practice. That was insured by making sure that the interviewed person had a direct interaction with BIM practice in their organizations.
- Has knowledge and understanding of PMC role in construction projects. This requirements ben satisfied by ensuring that the interviewed person worked in more than one project where there was a PMC practice in these projects.

- Worked in same project where PMC organization was of large scale organization (100+ employees) as it was justified earlier in this research chapter 4 section 4.9 that large scale PMC organization were considered as approaching small scale PMC organizations will not benefit and will negatively affect the research

Among these ten participants, 4 were PMC, 2 Contractors, 2 BIM Managers, and 2 Clients. The sample was so chosen because of the richness in data and opinions that it would generate. It is important, in a qualitative enquiry, that there is no data saturation and that valuable information is generated by every participant.

Most of the participants had more than 10 years of work experience in their relevant positions. Increasing the number of PMCs or any other group of participants would have led to data saturation. Data saturation occurs when there is no new information that is generated as a result of having a larger sample size that produce similar answers to questions (Kvale, 2008). In addition, it can be said that data saturation is reached when there is ample information to duplicate the study (O'Reilly & Parker, 2012). Furthermore, Mason (2010) has stated that data saturation occurs when further data collection provides diminishing returns. It is for this reason that Kvale (2008) suggested to use a minimum of 2 participants and a maximum of 15 participants. It can be observed that the sample applied in this study rests comfortably between the ranges of 2 to 15. Vandecasteele et al. (2015) have stated that after the tenth interview in their study, no new information was found as data saturation was reached.

In addition, this study also emphasized the need of quality information rather than the quantity of information that would be generated from the sample. Furthermore, since the sample was purposively selected to include individuals with more than 10 years of work experience in their respective fields, the sample can also be considered a representative of the construction industry as a whole.

With respect to the data analysis, the steps that are involved in thematic analysis were followed. In essence, the first step was the familiarization with the data. This was carried out by listening to the audio recordings of the interviews and by transcribing them. The second step that was applied was the generation of codes. Due to the nature of this research and the validation process, the codes generated were simple and were categorized based on changes requested to the framework or no changes requested. The categorized interviews were then analysed and a report was generated outlining all the changes that were requested by the participants based on the initial framework. The next step was to adjust the framework by the changes that some of the participants suggested by first asking the opinion of the other participants and by ensuring only those changes are made that were agreed upon by the majority.

The first aspect to note is that the combination of experienced PMC professionals, clients, and contractors who were also experienced and knowledgeable in BIM resulted in a small sample size. Furthermore, the quality of each of the interview maximized variety due to the number of years of experience each participant had in the industry. In addition, during the interview for validation, the participants were all agreeing to the framework and were not generating any new information. Thus, it can be said that data saturation was reached with these participants and hence, no further recruitments were made for the interviews. It should also be noted that the validation of the framework took place over several sessions with the participants. For instance, when PMC1 suggested an addition, that suggested was showed to all of the participants to gain their inputs. When they agreed, the requested change was carried out and the framework was shown to all of the participants again to gain more inputs. This process was carried out until there were no more changes suggested. Thus, the process of validation was rigorous and thorough.

6.5 Validation of the Framework

After producing the proposed prototype for the frameworks of PMCs roles and responsibilities related to BIM at each stage of projects lifecycle, it is essential to testify it in order to verify the validity of the findings. In this part of the study, ten interviews have been conducted to verify the research findings are discussed. The case studies are based on comprehensive semi-structured interviews with the head of BIM in project management organisations.

As stated above, each of the interviewee was presented with the framework and asked their opinion on it. Each of these interviews involves an explanation of the research and current findings. A comprehensive discussion is conducted for each interview, with the interviewed experts about functions and tasks for each stage of the framework that is developed based on the research findings. Expert opinions for each task and function of the framework is recorded and incorporated in the framework where necessary.

Figure 6.6 illustrates how the study reached the validation phase from the stage one of the literature review. The study has reached stage 4 and is now conducting the validations

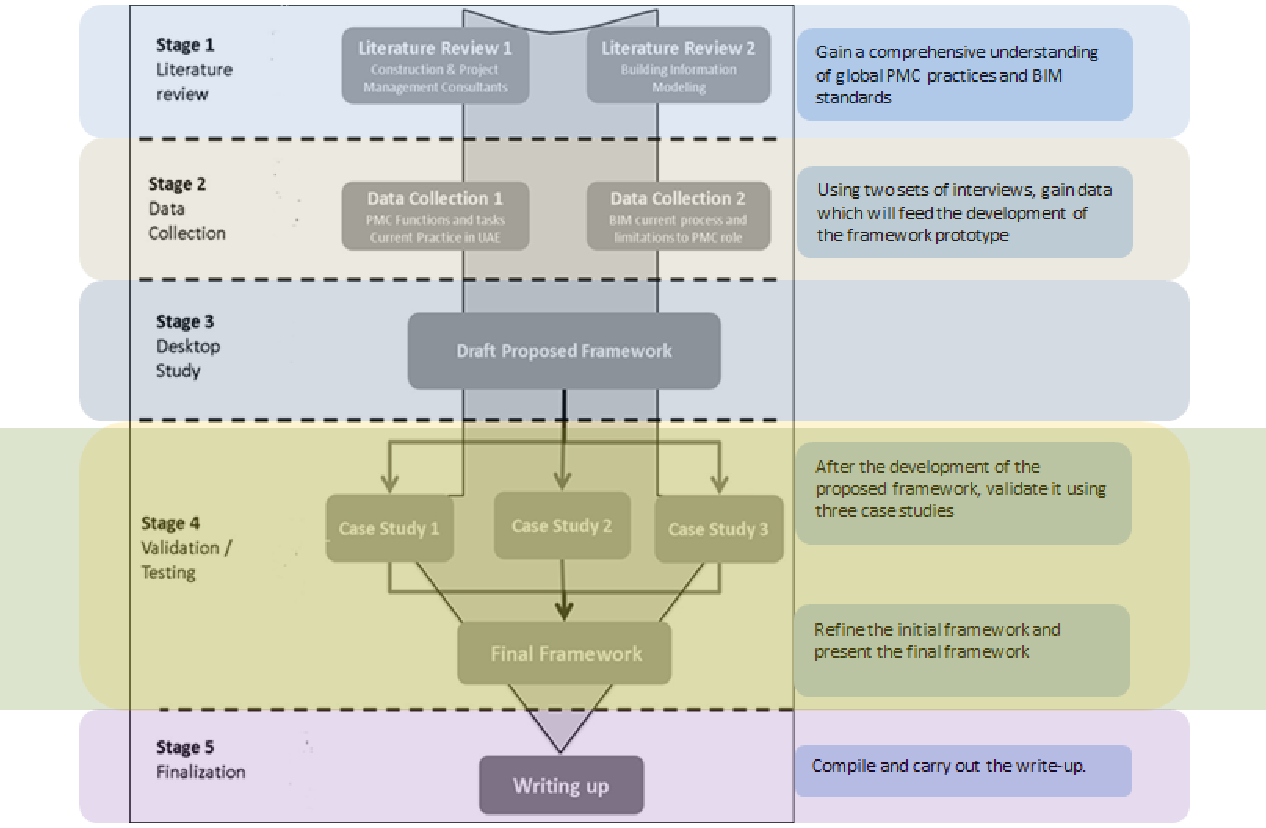


Figure 6.6. Stage of research in the process

6.5.1. Interview group 1

This will be in the form of semi-structured interviews. The first interview group consisted of four leading Project Management Consultancies. The interview was undertaken with a heads of BIM division in the Project management consultancies. The discussion went through the findings where the new functions and task were discussed in details as follows.

Pre-design Stage

The interviewees agreed that the new function would be BIM management which consists of three tasks. However; the interviewees proposed more details for each task.

Task 1

This task entails reviewing, editing and commenting on the Employer Information requirements along with drafting the project BIM strategy. It was emphasised that the project BIM strategy must include protocols, procedures and standards to be used. Moreover; interviewees advised that it some cases client might not have a developed EIR where in that case such responsibility transfers to the project management consultant to develop the projects

EIR. Such exercise would be accomplished by initiating a questionnaire to different departments of the client's organisation along with a meeting with relevant stakeholders in order to find out their expectation.

Task 2

Draft BIM scope for designer and consultant which has to be in line with project strategy and Employer information requirements.

Task 3

Review the BIM section in designers' pre-qualifications. The interviewees emphasised here that such review will definitely involve drafting the questionnaire to the bidders which based on it their BIM capabilities will be judged against. Moreover; the interviewee recommended referring to the CIC protocols where BIM capabilities are described and could be used as a basis for evaluating BIM capabilities for bidders.

Based on the above summary of responses given by the ten participants of this study, it was clear that there was an agreement on the tasks that need to be carried out during the pre-design stage. There was almost a unanimous agreement between all the ten participants regarding this stage.

Design Stage

The discussion moved forward to the next stage which is the design stage for the projects life-cycle. Again, the interviewee agreed that a new function would be added to the current framework which is BIM management. This function consists of 3 tasks.

Task 1

Review and approve the designers BXP. The interviewees agreed with the current findings that project management consultant should be reviewing, commenting and approving the designers submitted BIM Execution Plan.

Task 2

Manage BIM development process. The interviewee agreed that this is an essential task of the project management consultants which is executed through regular meetings and correspondences for BIM development in the project.

However; the interviewee emphasised that this task should include review and audit the quality of the BIM model as its being developed. That is conducted by verifying that data are there and ensure clash exercise is progressing as specified. It is highlighted by the interviewee that this part of the review could be referred to the description of "Information Manager" duties and responsibilities in the CIC BIM protocol.

Task 3

Manage BIM related parts of contractors' tender process. Again, the interviewee agreed to this task but added that the same process used with the consultants' tender stage should be repeated including questionnaires to investigate contractors BIM capabilities.

It was highlighted by the interviewee that the above tasks could be more organised by specifying at which part of the design stage it occurs. Accordingly, the interviewees recommended that task 1 should be at the concept design stage while task 2 is contentious task through concept; schematic and detailed design stages. As for task 3, it was recommended that it would be only at the latest part of the design stage which is technical design as well-known as detailed design stage.

The above tasks present a summary that was extracted from the responses of the participants. There was a unanimous agreement between the respondents about what the PMC's tasks should be. For all of the tasks, various respondents provided their views and analysis which were taken into account and presented in the above description. One of the most common comments that was received was that the tasks need to be organized in a highly efficient manner and the corresponding design stage should be identified.

In addition, one of the respondents stated that there needs to be a technical review of the model during the design stage. However, the majority of the participants found no need for the same and hence, it was not considered.

Construction Stage

Moving on with interviews up to the construction stage of the project's life cycle, the interviewees again agreed that BIM management function is an addition to the project management consultant roles and responsibilities. Going through the 3 subsidiary tasks; the finding was the following.

Task 1

Review, comment and approve contractors BIM execution plan. The interviewee agreed that that this task is part of the project management consultant role in the project.

Task 2

Manage BIM process, practice and implementation during the execution stage of the project. The interviewee agreed that this is an essential task of the project management consultants which is executed through regular meetings and correspondences for BIM development in the project.

However; the interviewee again emphasised that this task should include review and audit the quality of the BIM model as its being developed. Again the interviewee advised that this is conducted by verifying that data are there and ensure cashes exercise is progressing as specified. The interviewee again recommended that this part of the review could be referred to the description of "Information Manager" duties and responsibilities in the CIC BIM protocol. However; there is one comment by interviewee which is limiting the review process by project management consultants to verify that data is available; however, the supersession consultant is the responsible party that data are accurate.

Task 3

Manage coordination between internal and external stakeholders of the project. The interviewee agreed the same as it is by default is part of project management consultant normal practice not limited only to building information modelling.

Close Out Stage

The last stage of the project lifecycle. Similar to the above discussed stage; the new function by the project management consultants will be BIM management. At this stage, it will be limited to one task only.

Task 1

Manage the process of handing over BIM deliverables. The interviewee agreed that this task is an essential part of project management consultants' roles and responsibilities towards BIM practice in the project.

Notably, the interviewee recommended for extension of the PMC role towards BIM beyond the close out stage. Specifically, the interviewee highlighted that there PMC has a BIM role in the handing over the stage. This role entails working with facility management department at the operation stage of the project lifecycle for a short period in order to ensure that the delivered BIM data are workable.

All of the tasks were developed in tandem with the responses of the respondents and hence, the above have been unanimously agreed upon by the participants.

6.5.2. Interview group 2

The second interview was conducted in collaboration with two prominent contracting companies in Dubai, UAE and two BIM Managers. In a similar approach to the other interviews, the discussions with the respondent started with an evaluation of the proposed new functions and tasks and proceeded to the validation process.

Pre-design stage

Based on the interview, the respondents agreed that each of the three BIM tasks for PMC were relevant. However, several insights into how these tasks would be efficiently undertaken were also provided.

Task 1

It was explained to the interviewee that this task would entail reviewing, editing and commenting on EIR as well as drafting the project's BIM strategy. The interviewee within this context emphasised the importance of a detailed review process that should ensure that all project-specific requirements are taken into account. According to this interviewee, a comprehensive EIR review should cover three key areas which include technical, management and commercial areas of BIM. As highlighted by the interviewee, the technical aspects of the EIR should cover software platforms, data exchange format and level of detail. Management should, on the other hand, revolve around the BIM standards, roles and responsibilities, security, systems performance and compliance plan among others. Lastly, the commercial area should include important aspects such as the client's strategic purpose, the BIM deliverables and a competence assessment of BIM.

Task 2

In relation to task two, it was explained that PMC would be responsible for drafting the scope for design and consultant while ensuring alignment with the project strategy and EIR. The interviewee agreed that this task was crucially important in terms of preparation for an efficient design stage.

Task 3

This task involves reviewing the designer's pre-qualifications in the BIM section. The interviewee noted that the pre-qualification process is one of the areas where challenges are encountered. This was attributed to the lack of an agreed upon BIM qualification criteria. Nonetheless, the interviewee highlighted a number of aspects that should be present in all BIM pre-qualification assessments. The first of these areas include the BIM competence levels of the consultants and designers in terms of knowledge, skills and experience that is required in the effective delivery of BIM. The second area was in relation to the designer's capacity and resources. Here, the interviewee explained that it was important for the designer to demonstrate the availability of human and technical resources that are required to deliver BIM. The third aspect covered the soft areas of the organisation which include a culture that drives the designer or consultant to be willing to effectively deliver BIM. Lastly, the pre-qualification criteria should include the cost of delivering BIM in which case it was agreed that a reasonable cost should be charged.

Design stage

In line with the construction project lifecycle process, the next discussion revolved around the design stage. In this part, the interviewee also agreed that BIM management and its subsidiary tasks were all important and further added a few insights on how to go about these tasks.

Task 1

Review and approval of the designer's BIM execution plan. While agreeing on the need for PMC to review, comment and approve the BIM execution plan submitted by the designer the interviewee argued on the need to address some specific issues. For example, the interviewee advised that during the review process PMC should ensure that execution plan provides detail information as opposed to simple statements. The rationale was that detailed BIM execution plan information was necessary for avoiding misunderstandings on how to undertake the BIM project. It was also indicated that prior to approval of the plan, the PMC should be confident that the designer and his team has the required capabilities. Lastly, the interviewee advised on the need to ensure that the BIM execution plan that is submitted by the designer is commensurate with the BIM proficiency that is required for the given construction project.

Task 2

Managing the BIM development process. As part of this task, the interviewee emphasised that PMC needs to ensure that the designer makes use of the appropriate tools for BIM functions such as clash detection and environmental analysis using 4D and 5D. In addition, the interviewee was categorical that PMC should assess whether an iterative process has been used to ensure compliance. In terms of approach, it was recommended that PMC should be involved in the managing of the interactive design team meetings that are required in the BIM development process. The aim is to ensure issues that arise during the development process can be resolved proactively as opposed to reactively after completion of the process.

Task 2

Management of the BIM development process. The interviewee concurred that this was an important task for PMC to undertake. In consistence with other case studies, one of the emphases in relation to this task was that PMC should ensure that the designer makes appropriate use of the various tools required in the BIM development process. Accordingly, the model development should be capable of supporting a range of functions include clash detection, coordination between various multi-disciplinary teams and 4D and 5D CAD among others. It was further emphasised that PMC should perform an active role in managing the BIM development process rather than providing inputs only in the form of reviews.

Task 3

Management of BIM related parts of the contractor's tender process. The interviewee agreed that the main role of PMC, in this case, should be an evaluation of the contractor's BIM capabilities during the tendering process. In order to enhance preciseness in this task, it was advised that PMC should lookout on whether the tenders demonstrate that the contractor is capable of using BIM to create a visualisation effect which enables for making of effective time schedules. The contractor should also demonstrate the ability to use BIM for purposes of making faster quantity takeoffs. PMC should make use of questionnaires in the assessment as well as a request for supportive documents on BIM.

Overall, it can be seen that the interviewee agreed with each of the three tasks that constitute the PMC BIM role in the design stage. There was, however, an emphasis on the need to make use of a detailed approach in review the BIM execution plan; the need for PMC to ensure that the designer can make use of the most appropriate tools in the BIM development process; and ensuring that contractors have the necessary BIM capabilities during the tendering process.

Construction stage

In the next stage of the construction part of the project lifestyle, the interviewees were briefed on the identified PMC tasks in relation to BIM. In specific, it was highlighted that the main PMC role revolves around management. Based on the responses by the participants, analysis was conducted and the discussion of the three subsidiary tasks was then conducted as follows:

Task 1

This task requires PMC to review, comment and approve the contractors BXP. The interviewee agreed that this was indeed a crucial task that contributes to the overall success of BIM in the construction project life cycle. The interviewee further offered several inputs that PMC should take into consideration while undertaking this task. First, it was emphasised that there is usually a tendency for contractors to come with their own standard BIM processes that they intend to use as part of the execution plan. According to the interviewee, such BIM may conflict with the BIM execution plan provided by the designers. It is therefore important for PMC to ensure that the BIM execution plan provided by the contractor is based on earlier execution plans provided by the designer. This not only reduces the time involved in drafting the plan but also reduces the likelihood or errors and inconsistencies between the designers and contractors BXP.

Task 2

The interviewee was informed that this task would revolve around management of the BIM process, practices and implementation during the execution stage of the project. In relation to this task, the interviewee's main emphasis was on the need for PMC to collaborate with the contractor to ensure effective use of BIM during the construction phase. In specific, the interviewee pointed out that PMC should ensure that PMC is able to save time by using BIM to facilitate real-time information to resolve complex tasks or problems. PMC should also conduct own assessment such as clash detections on all models under use by the contractor.

Once problems have been identified PMC should hold a meeting with the contractor to discuss possible solutions and their implementation.

Task 3

Coordinating internal and external stakeholders. The interviewee expressed the belief that PMC had an important role in terms of ensuring effective coordination of the internal and external BIM stakeholders. In consistence with earlier findings in Chapter 5, the interviewee reinforced that coordination was important in the construction phase due to the presence of multi-disciplinary teams which require efficient communication and information flow in order to ensure that BIM leads to an effective process.

Close out stage

The final part of the discussion was in relation to close out which is the last stage of the project lifecycle. The interviewee was informed that one PMC function involving BIM management had been identified. The accompanying task and the discussion were as follows:

Task 1

Managing the process of handing over BIM deliverables. The interviewees provided consent for this role and also offered a few insights on how PMC should go about this task. According to this interviewee, PMC should ensure that all project related information that is relevant to the client or facilities manager should be provided in the complete design model. Examples of such information as indicated by the interviewee include the graphical data, maintenance instructions, commissioning records and COBie information exchange.

6.5.3. Interview group 3

The third interview was undertaken with the help of two clients in the UAE. The interviewee was adequately briefed on the nature of the framework protocol that identified the new PMC roles with BMI in the various phases of a construction project lifecycle. The interviewee was then requested to offer views on the validity of the findings.

Pre-design stage

The respondents were taken through the three tasks related to BIM management at the pre-design stage. The relevance of the tasks and the need for changes or modifications were then discussed. This section highlights the key views of the interviewee.

Task 1

The interviewee agreed that PMC was indeed required to perform an active role in reviewing, editing and commenting on EIR as well as the drafting process of the BIM strategy. In this context, it was emphasised that the EIR should be comprehensive enough to enable the other parties to the project to produce their initial BXP. Due to the lack of adequate knowledge of BIM by most employers, the interviewee advised that PMC should provide professional advice in this area. In relation to BIM strategy, some of the things that came up included the need to ensure that the project is set up correctly through the presence of a clear statement of the objectives for using BIM, identification of outputs required by the client and the process of appointing a BIM coordinator among others.

Task 2

This task entails drafting the scope for design and consultant and ensuring consistency with project strategy and EIR. Again, the interviewee agreed that the task was important for PMC. During the process of drafting the scope, the interviewee indicated that it is crucially important for PMC to collaborate with both the designers and consultants.

Task 3

Review of designer's pre-qualification. Given that BIM is still a relatively new concept among some construction stakeholders the interviewee underscored that it was crucial to assess the qualification of the designer before proceeding to other stages such as tendering. Such assessment should be wide ranging and include aspects such as the designer's maturity levels, competencies and granularity levels among others.

Design Stage

The next part of the discussion moved to the design stage of the construction project lifecycle. The respondent was informed that three subsidiary tasks related to BIM management had been identified. In this part, the views of the interviewee in relation to the use of BIM by PMC in this stage are outlined.

Task 1

Reviewing and approving the designer's BIM execution plan. There was an agreement during the discussion that it was important for PMC to spearhead the process of reviewing and approval of the BXP submitted by the designer. Among the issues that the interviewee recommended for review include the extent to which the language and format used in the BXP can be used effectively in later stages by important stakeholders such as contractors. In other words, the designer should provide a BXP that take into account the needs of other parties in the later stages of the construction process. The specific details for assessment include the model content (e.g. 3-D representation), level of detail provided for each of the project milestones and the protocols and procedures to be used.

Task 3

Managing BIM related parts of the contractor's tender process. The interviewee noted that this was one of the most important tasks for PMC at the design stage since it helps establish the contractor's BIM competence or capabilities. In light of such importance, the interviewee indicated that robust methodologies should be used in evaluating BIM capabilities during the tendering process. It was also indicated in the discussion that effective assessment of BIM parts in the tender process was necessitated by an on-going trend whereby contractors and other suppliers falsely claim their BIM competence only to fail to deliver effectively.

Construction stage

The discussion with the interviewees progressed to the construction stage. Here, the interviewees were informed that in relation to the role of PMC in BIM management three subsidiary tasks had been identified. The respondent offered several insights as to the validity and necessity of these tasks.

Task 1

Review, commenting and approval of contractor's BIM execution plan. The interviewee agreed that it is indeed the role of PMC to ensure that the contractor's BXP is comprehensively reviewed and approved. In order to effective in performing this task, the interviewee added that PMC should ensure that the contractor makes use of an approved BXP format that is also consistent with plans used in earlier stages such as design. Based on the experience of this interviewee it was further advised that PMC should require the contractor to state the various intentions of using the model. In addition, PMC should not consider the contractor's BXP as final but rather a document that needs sharing with other stakeholders in order to achieve greater levels of integration with teams such as the design team who are responsible for the preconstruction phases.

Task 2

Management of the BIM process, practices and implementation at the execution stage. The interviewee also agreed that this task was crucial. It was further emphasised during the discussion that the management process during the construction phase should give emphasis to ensuring that BIM gives rise to higher efficiency, reduced risks and cost improvements.

Task 3

Coordination of internal and external stakeholders. In relation to this task, the interviewee held the view that PMC should be involved in the coordination of BIM meetings where internal and external stakeholders from various disciplines are brought together. It is at these meetings that PMC should address common issues such as file naming and transfer convections as well as software versions for use. According to this interviewee, an effective BIM coordination process could help avoid mistakes in areas such as Clash analysis where lack of coordination could lead to a wastage of BIM lead time and distract the various teams from identifying the real problems affecting the project at the construction stage.

Close out stage

In a similar way to other interviewees, the respondent has informed that as part of this final stage of the project lifecycle one task related to BIM had been identified. The interviewee was then requested to offer additional views on the necessity of this task.

Task 1

Handing over of BIM deliverables: the interviewee was in agreement that PMC has an important role in facilitating the handover of BIM delivers during the close-out stage. While referring to soft landing activities as one of the important aspects of the close out stage, the interviewee further explained that PMC should assist in this process by coordinating the release of the end of construction BIM record model data. The interviewee also added that prior to the hand over process the PMC should review the project performance in light of the projected BIM data.

6.6 Contributions of Validation

The first interviewee, a PMC 1, stated that it is important for the PMC to prepare the questionnaire to gather client's requirements and expectations, and share it with the client's department to obtain the relevant BIM requirements and expectations. Noting this point, the researcher asked the opinions of the other PMCs. They all agreed on the suggested change by the PMC1. Other participants were consulted on the suggestion provided by PMC 1. All of them agreed that the PMC needs to be involved in gathering client's requirements and BIM expectations. Therefore, this point was added as the first step in the framework.

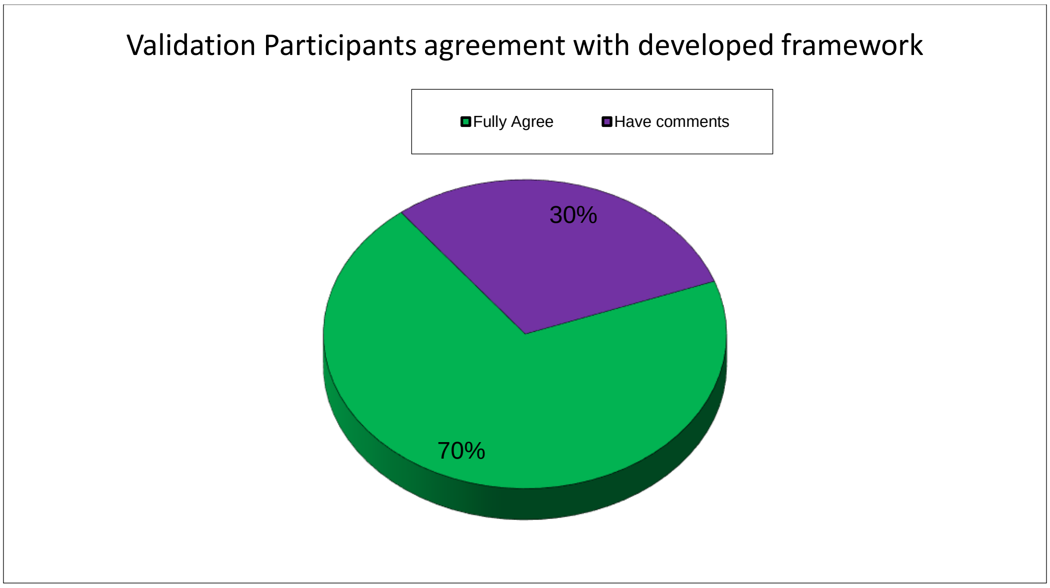


Figure 6.7 Participants' agreement with the framework

As can be seen from the above figure, 30% of the participants had further comments on the revised framework.

The first comment on the framework that was received was that the PMC needs to be involved well into the operations or the Facilities Management stage. This was an important point and it was posed to the other participants to gain their opinions as well. Figure 6.8 below demonstrates that the majority of the participants were in complete disagreement with this change and hence, this change was not applied to the final framework.

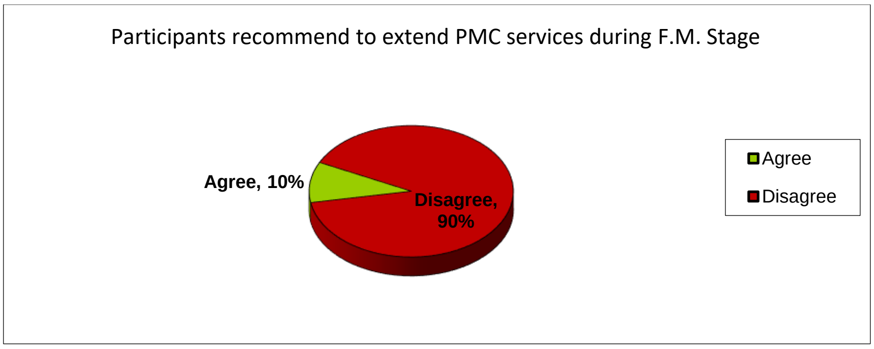


Figure 6.8 Participants recommend extending PMC services during F.M. Stage

Further to this, another participant, PMC2, suggested that the technical review should be a crucial part of the BIM process. In a similar manner to the above, all other participants were asked if they agree with this or not and the results are presented in figure 6.9 below. Due to a majority disagreement, no changes were made to the framework. The majority agreement for this was inline with the literature review findings where it was clarified that PMCs have been described as *"clients' advisor who leads the project"* according to the definition by Chartered Institute Of buildings (CIOB. 2002), additional with literature finding that PMC are defined as *"a client advisor who leads, coordinates, supervises, and manages all the organizations in the project in order to achieve the project's objectives"* (Kerzner, 2001; Meredith and Mantel, 2000; Bennett, 1983). Additionally; it is in agreement with first round of interviews where it was agreed that PMC organization does not hold technical liability nor conducting a technical review of delivered design as a response for Q8 in chapter 5.

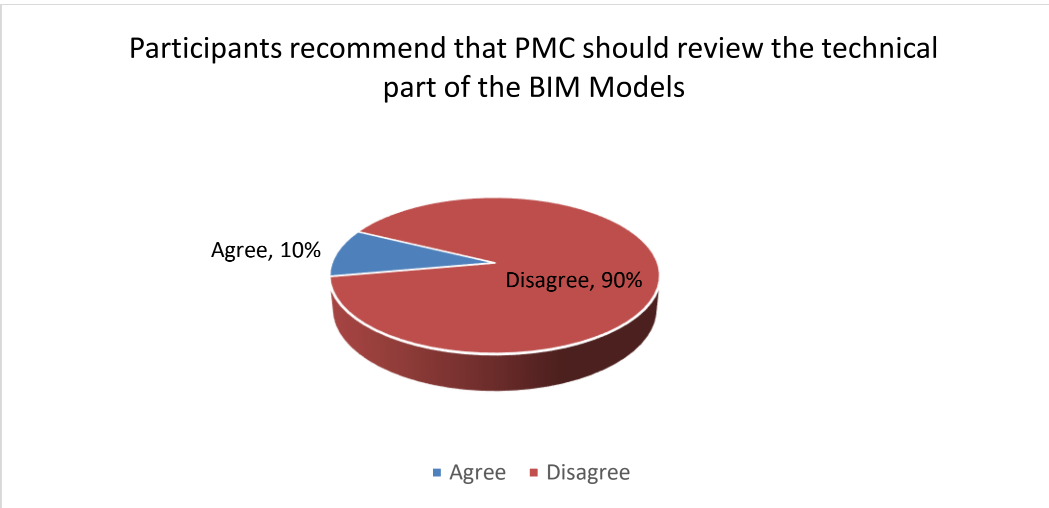


Figure 6.9 Participants recommend that PMC should review the technical part of the BIM Models

Finally, one of the participants, Contractor 1 stated that the PMC needs to be involved before the pre-design stage during the feasibility study. This was also asked to the other participants and the majority of them disagreed. Hence, no changes were made to the framework.

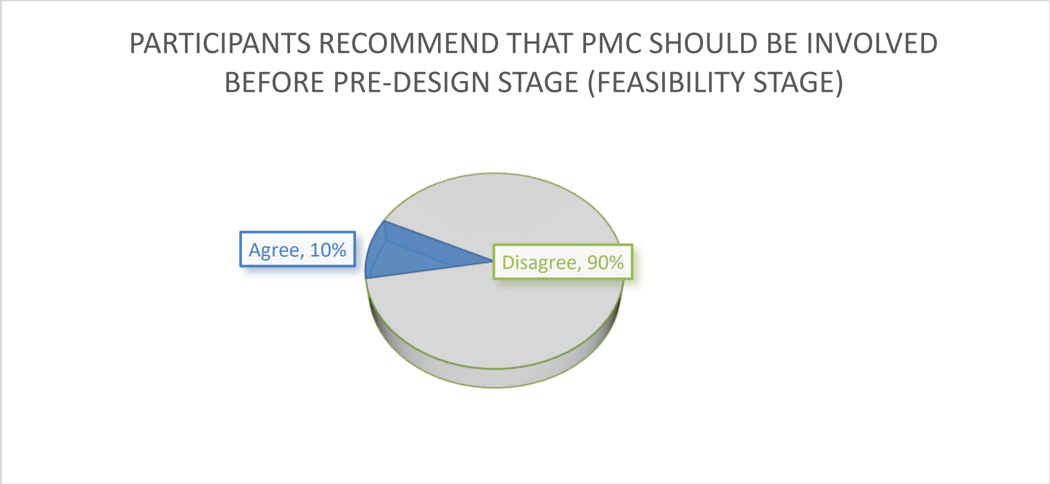


Figure 6.10 Participants recommend that PMC should be involved before pre-design stage (feasibility stage)

In order to identify various discrepancies and disagreement between various input of different interviews; a quantitative table been produced to summaries differences if inputs and to identify if has been agreed by other stake holders and finally if it was incorporated in the final framework. The approach was calling all other participants and explaining the different input by certain stake holder. If majority of other participants agreed; then the frameworks would be updated to adopt the change. If the input was disagreed by majority; then the in pout will be neglected and ignored from the final framework as it would be reflecting a single opinion of the participant which would not be suitable for wider range of organizations.

Participant Code	Knowledge of PMC	Knowledge of BIM	Correction Suggested	Agreed Upon by Other Participants	Final Action updating the framework
PMC1	Yes	Yes	Yes - To prepare the questionnaire to gather client requirement before the pre-design stage begins.	Yes	Yes
PMC2	Yes	Yes	Yes - We need to be involved after the handing over stage during the operations	NO	NO
PMC3	Yes	Yes	No	N/A	N/A
PMC4	Yes	Yes	No	N/A	N/A
Contractor 1	Yes	Yes	Yes - The PMC needs to be involved before the pre-design stage during the feasibility study.	No	NO
Contractor 2	Yes	Yes	No	N/A	N/A
Client 1	Yes	Yes	No	N/A	N/A
Client 2	Yes	Yes	No	N/A	N/A
Consultant 1	Yes	Yes	Yes - the technical review should be a crucial part of the BIM process	No	NO
Consultant 2	Yes	Yes	No	N/A	N/A

Table 6.1. Summary of changes requested to the final framework during validation

6.7 Chapter conclusion

The main aim of this chapter was to validate the framework prototype with the use of interviews. All the ten respondents agreed with the contents of the framework in terms of suitability and applicability in a real PMC setting. In relation to the pre-design stage, three tasks related to BIM management by PMC were agreed upon: (1) reviewing, editing and commenting on EIR and drafting the project BIM strategy; (2) drafting BIM scope for designer and consultant; and (3) reviewing BIM section in designers' pre-qualifications. Some of the emphasis in these tasks included the use of questionnaires to evaluate the bidder's pre-qualifications and the need to undertake a comprehensive EIR review process that takes into account technical, management and commercial areas of BIM.

In relation to the design stage, three tasks were also agreed upon by the majority. They include: (1) reviewing and approving the designer's BXP; (2) managing the BIM development process; (3) managing BIM related parts of contractor's tender process. In one of the case studies, it was recommended that task 1 could better fit at the concept design stage. Other interviews, however, indicated that review of BXP was still applicable at the design stage. Some of the key emphasis in this part included the need to evaluate the designer's BIM capabilities and the need to use interactive design team meetings during the management of the BIM development process. One PMC consultancy stated that it would be appropriate if the PMC was involved during the pre-design stage; however, the majority of the participants in this study supported the above tasks presented. In addition, one of the participants stated that there is a need to carry out a technical review of the model during the design stage, but the other participants did not feel it was necessary. Hence, it was not considered.

At the construction stage, three PMC tasks in relation to BIM development were also validated. They include: (1) reviewing, commenting and approval of contractor's BXP; (2) managing BIM process, practice and implementation during the execution stage of the project; and (3) managing the coordination between internal and external stakeholders of the project. The emphases by the respondents revolved around the need to ensure consistency between the designers' and contractors' BXP and addressing of common issues such as file naming and transfer convections during the coordination meetings.

Lastly, in the close-out stage, the single BIM task identified in the framework prototype was validated. It was, in particular, agreed that PMC would be responsible for managing the process of handing over BIM deliverables. Only one of the respondents suggested that PMC role in BIM management could be extended beyond the close-out stage to operations stage where PMC would assist the facility manager in handling BIM data in the period after hand over. Other respondents did not consider it necessary for PMC to be involved in BIM management after hand over and hence this role was not included in the final framework. Figure 6.6 provides an overview of the validated framework.

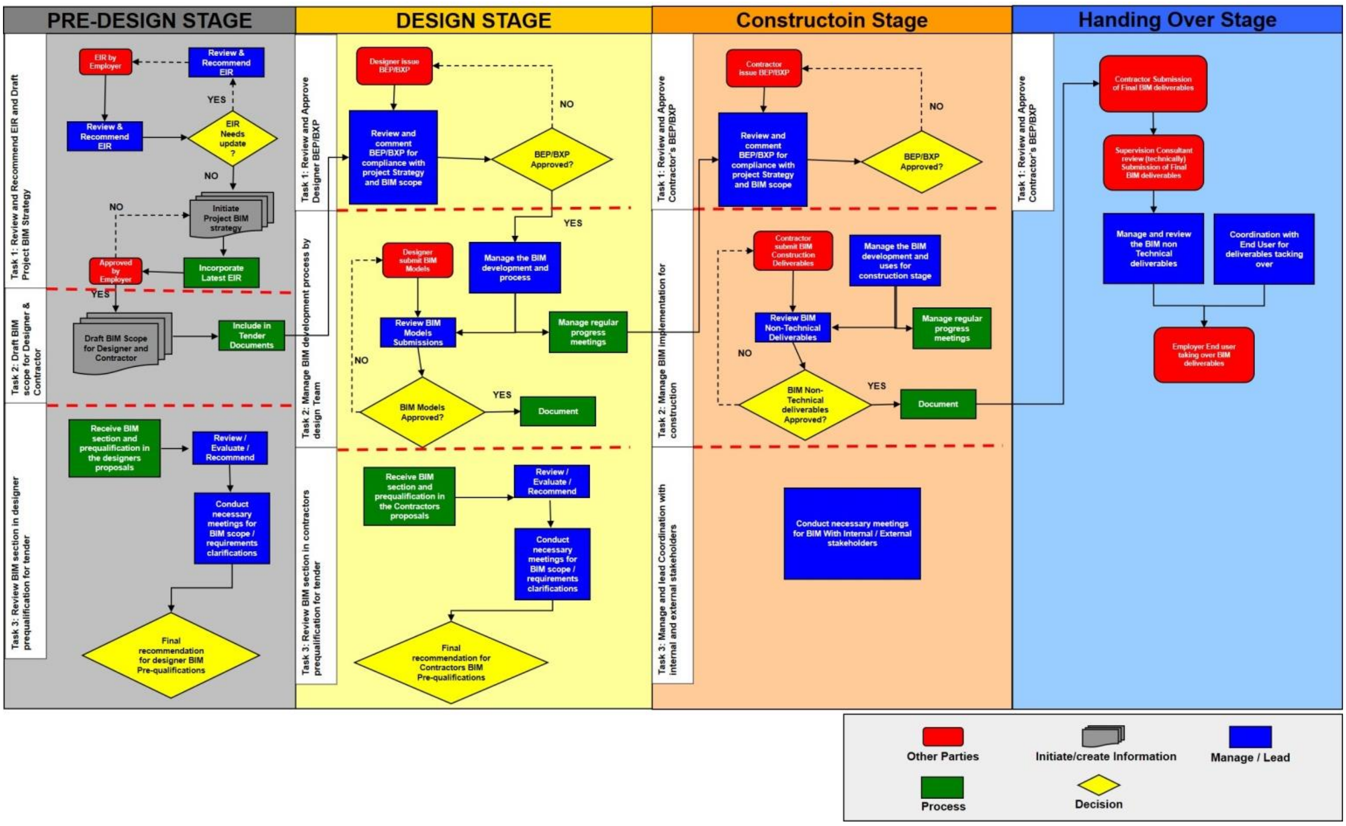


Figure 6.11. Final framework of PMC BIM functions and tasks

The three groups of interviews conducted between the ten participants of this study were presented above. In these three groups, there were very similar responses which showed that there was an understanding of the core activities that a PMC has to undertake starting from the pre-design stage to the handing over stage.

For task 1 of the pre-design stage, all of the respondents stated that there was an importance in reviewing, design and commenting on the EIR. One of the respondents stated that if the EIR has not been developed at that stage, then it becomes a core aspect of the PMC function to develop the same. For task 2 and task 3 of the pre-design phase, the participants had similar answers and stated that the BIM scope for the designer and the consultant needs to be outlined with great detail and in great emphasis. Additionally, the BIM section should be reviewed carefully. In addition to these tasks, EIR review which takes into account the technical, management and commercial areas of BIM needs to be conducted.

For the design stages, an agreement was found for the three tasks that have been developed. However, one disagreement was that task 1 of the design stage was better if it were moved to the concept design phase. However, other respondents stated that this task was still applicable and important by reviewing the designer's BIM capabilities and the need to use interactive design team meetings during the management of the BIM development process. One of the participants also stated that there was a need to carry out a technical review of the design model but the other participants did not agree, hence, it was not considered.

During the construction stage, the emphasis was placed on the maintaining a consistency between the designers' and contractors' BXP and addressing of common issues such as file naming and transfer convections during the coordination meetings. In addition, the tasks that are presented above were validated and confirmed.

Finally, in the last stage of the process, there was an agreement that the PMC would be involved in the handing of the BIM deliverables. There was one respondent who stated that there was a need to involve the PMC after the hand-over, however, the majority of the participants did not consider it important and hence, it was not included in the framework. The remaining tasks were subsequently added and validated.

Chapter 7

7.1 Discussion and conclusions

This research sought to develop a BIM management framework that would assist in the enhancement of PMC's role and practice in relation to the UAE construction industry. The rationale for undertaking this study was based on the observation of the poor performance of the construction industry and the lack of coherence of PMC's involvement which could be overcome through more effective utilisation of BIM. Following the collection and analysis of relevant data, this final chapter provides a discussion and draws conclusions on important areas that were covered in the research. The chapter is structured around each of the objectives that were outlined in the introductory chapter. The chapter also provides a general conclusion as well as a discussion of the limitations encountered during the research and directions for future research.

This thesis has an important contribution in the Construction industry for enhancing the productivity of the industry. It has been identified in this study that no uniform understanding of what the role of the PMC is exists in the industry. This has been greatly impacted by this study now as a clear outline of what the roles and responsibilities are for the PMC. In addition, the right stage at which the PMC is involved in, which is the pre-design stage, has been outlined. In addition, as the study's framework has been validated, it can be applied in the construction industry and the changes that occur in the rate of productivity can be analysed.

There was no standard or approach explains how Project Management Organization would efficiently contribute to to the BIM process and practice within project lifecycle. This unique approach / framework which contribute to the knowledge by identifying new functions and subsidiary task by PMC organization where thay can enhance the overall projects performance as well as BIM process.

The contribution of knowledge of this thesis is substantial. First, through its literature review, the thesis brings together and consolidates information regarding the role of the PMC. Second, it uses a unique approach which is the framework development and validated the framework so that it can be applied to the industry. In addition, it has opened up avenues for future research substantially.

7.2 Findings regarding the research objectives

7.2.1 Construction industry performance and PMC role

The objective of the study involved a review of the performance of the construction industry and the PMC role. From the review, it was found out that in the past few decades performance in the construction industry have remained generally poor compared to other industries such as manufacturing. The report by Egan (1998) comprehensively highlighted five main problems that affect the industry. These include lack of client satisfaction due to time and budget overruns; low satisfaction among the delivery team due to poor working condition; a poor reputation of the industry that is attributable to poor performance; low profitability; and lack of innovation and development. Despite these issues being effectively highlighted the present study found that they are yet to be addressed as highlighted in recent research (e.g. Xiong et al., 2014; Fulford & Standing, 2014; Oesterreich and Teuteberg, 2016 and Gosselin et al., 2016).

The lack of interoperability across the industry, in particular, contributes to the higher cost of transactions, low efficiency and quality and longer lead-times in the supply chain (Grilo et al., 2010). Among the solutions considered to be potentially effective in resolving this problem include the adoption of lean construction and integrated project delivery. Since BIM is developed around the need to achieve interoperability in the industry, it can also be concluded that increased use of this technological innovation is key in solving performance issues in the construction industry.

In relation to PMC role, the study indicates that PMC performs an important role in terms of ensuring that client requirements in terms of design and specifications are made available to the responsible parties and that the project is executed based on client objectives and within the cost and time requirements (Chartered Institute of Building, 2002). The study in this context concludes that construction projects that make use of PMC are likely to experience benefits such as clear leadership throughout the project, reduced in-house conflicts and disputes and non-vested interest advice. Challenges such as the need to balance multiple and competing objectives, availability of resources, tensions between PMC and other stakeholders that constitute the AEC team may, however, be encountered (Bakker et al., 2013; McGivern et al., 2017).

Several upgrades will be required to ensure that the PMC is competent enough to handle the new roles that have been proposed by this framework. As the current scenario in the country points to the fact that the PMC has been involved traditionally only in the design stage, this framework proves that there is a need for the PMC to be involved in the pre-design stage. Hence, that is the first change that will take place in the PMC's conventional functions. In addition to the competencies that the PMC is required to have during the design stage, the PMC need to develop additional competencies which will be exploited during the pre-design stage. This includes the EIR review and in some cases development. It was identified that it's highly important to develop the EIR if the employer has not done so and to evaluate the bidder's technical requirements during the tender process. In addition, the EIR review must be completed for the technical, management, and commercial aspects as well. Finally additional specialized staff will been added to the organizations to address the new function and tasks related to BIM management beside training to the current employees to the new technologies.

7.2.2 Building information modelling evolution and practice

From the review, it was indicated that the evolution of BIM could be traced to dissatisfaction with 2D paper designs that were in use until the early 1990s (Eastman et al., 2011). BIM has helped overcome this and other problems associated with information exchange by allowing users to superimpose multi-disciplinary information within one model (Arensman & Ozbek, 2012; Demian & Walters, 2014). It also emerged from the review that the use of BIM in construction projects offers a range of benefits such as ease of updating the model, increased efficiency in quantity take-off and drawing documentation, better simulation of 3D, 4D and 5D models and operations such as emergency evaluation and heat transfer, as well as reduced cost and better conformation to time requirements (Nawari, 2012; Succar et al., 2012; Wong & Zhou, 2015). Greater levels of adoption of BIM are however hindered by its steep learning curve, lack of global standardisation and resource challenges especially in developing countries such as UAE.

In terms of practice, the review undertaken in this research indicates that BIM has uses across each of the key stages of the project lifecycle. It can, for example, be used for primary uses such as cost estimation, phase planning, design reviews and building system analysis as well as secondary functions such as mechanical analysis, code validation and digital fabrication (Haron et al., 2010). The review also highlights a growing trend in terms of BIM development where various countries around the world are developing their BIM standards. The UK and the

United States are key leaders in this area where they have put forward standards related to security of information, collaboration through information and information exchange (i.e. COBie).

7.2.3 PMC functions that can be supported through BIM

The third objective of the study was in relation to the exploration of PMC's current functions and frameworks and the identification of key functions that can be effectively supported by BIM. Based on interviewees with industry experts in the UAE construction sector, a number of important findings were made. First, BIM is used in over half of the projects, particularly in large and complex projects. Second, PMC is mainly hired at the design stage yet it should, in essence, be hired from the pre-design stage. Overall, the study concludes that PMC has important functions in each of the project lifecycles in both BIM and non-BIM projects.

It was noted that there were variances from the RIBA plan of work in stage descriptions, especially in relation to the design stage in which case PMC role was similar in all three stages. In addition, the involvement of the PMC in the strategic definition and use stages was missing. It is on this basis that the study developed an overlay of PMC role on the RIBA plan of work.

7.2.4 Framework for supporting main PMC functions utilising BIM

The fourth study objective was developed with the view of proposing a holistic framework that would help support main PMC functions utilising BIM so as to ensure maximum value for BIM. While following the steps included in the RIBA plan of work the primary function of PMC in relation to the use of BIM in the construction project was considered to be that of BIM management. The specific tasks in each of the stages are summarised in figure 7.1. These tasks were derived from the interview with the industry experts.

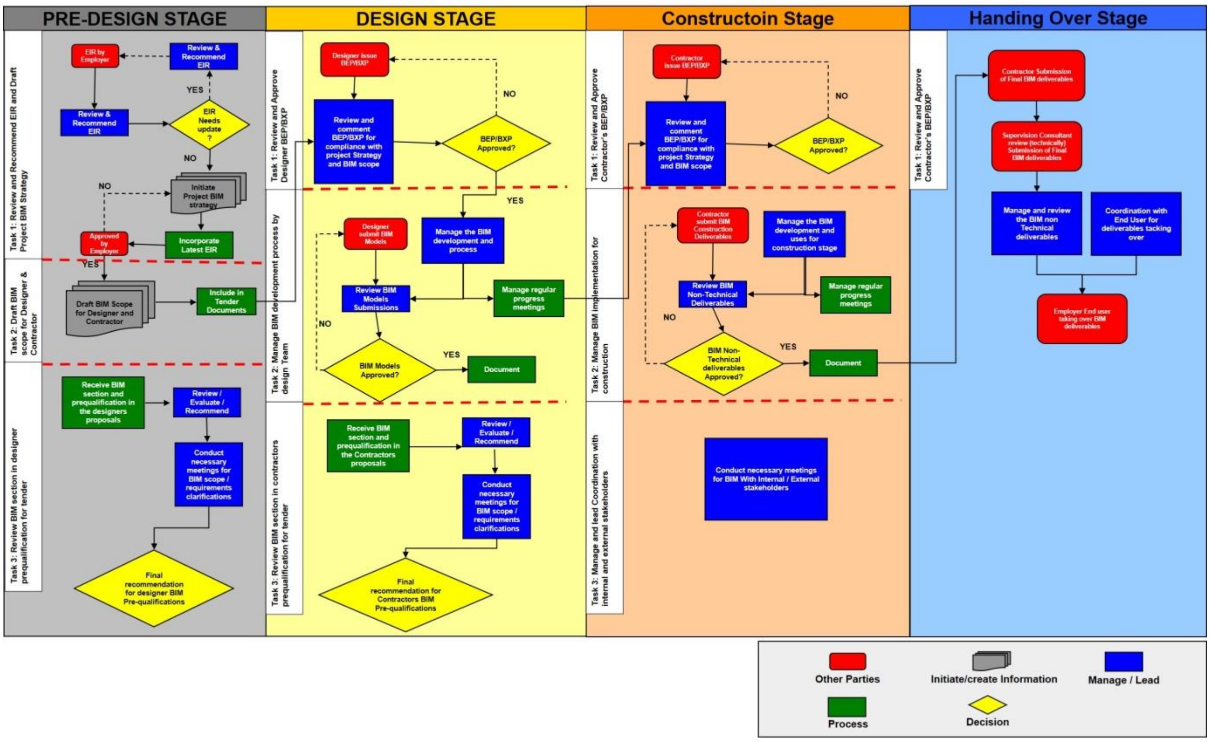


Figure 7.1: Proposed framework for incorporation of BIM practice for key PMC functions

During the Stage 1, there are three tasks of the PMC integrated within the BIM. These are:

- Task 1: To review, edit and comment on the EIR thereby drafting the project's BIM strategy. Here, the task commences when the employer provides the EIR which is then reviewed and any changes are noted and implemented. Once the EIR has been finalized, the Project BIM strategy is implemented and most recent version of the EIR is incorporated. Once the employer approves this, the next task is initiated. In the case where the approval is not met, the task moves back one step to allow the revision of the BIM strategy that was initiated.
- Task 2: To draft the BIM scope for the designer and the contractor. Once task 1 is successfully completed, the next step is to draft the BIM scope for the designer and contractor which is subsequently included in the tender documents. This step is connected to the Design Stage 2, Task 1.
- Task 3: To review the BIM section in the designers' pre-qualifications. Finally, the BIM section is received, and the pre-qualifications in the designers proposals are set. This is evaluated, reviewed, and changes are recommended. Final recommendations are made for designer BIM pre-qualifications.

During Stage 2, 3, & 4, there are three functions of the PMC:

- Task 1: To review and approve the designers' BXP. This stage commences with the designers issuing the BEP/BXP and ensuring that it is in compliance with the project strategy and BIM scope. The BEP/BXP is reviewed and if it is not accepted, it is sent through the process again until it is approved.
- Task 2: To successfully manage the BIM development process by the design team. Once the BEP/BXP is approved, the management of the BIM development and process commences. Here, this branches off into two steps: the review of BIM models submission and the management of regular progress meetings. The BIM models submission review is carried out when the designers submit them for review. If the models are not approved, they go through the cycle and do so until they are approved and finally, documented. Management of the regular progress meetings takes place independently of the other processes and has implications for Task 1 of the Construction stage.
- Task 3: To manage the BIM related parts of the contractors of the tender process. Task 3 is independent of the above tasks in this stage. Here, the task commences with the PMC receiving the BIM section and the pre-qualifications in the contractor's proposal. This is then evaluated, reviewed and changes are recommended. The required meetings for the BIM scope and requirements are conducted and the same clarified. This then moves towards the final recommendation for the BIM pre-qualifications which marks the end of this task.

During the Stage 5, the following three tasks are proposed to be carried out:

- Task 1: To review and approve the contractor's BXP. This task begins with the Contractors issuing the BEP/BXP. They then review and comment regarding the compliance with the project strategy and BIM scope. This task is similar to the task 2 of the design stages.
- Task 2: To manage the BIM practice during the execution stage. This task begins with the management of the BIM development and uses for construction stage which branches into two steps: reviewing the BIM non-technical deliverables and managing the regular progress meetings. The review is carried out after the contractor submits the BIM construction deliverables which after review and approval are documented. This documentation is an essential step of the handing over stage.

- Task 3: To manage the coordination between the internal and external stakeholders. This task is concerned with conducting the necessary meetings for BIM with the internal and external stakeholders.

In the final Stage 6, there is only one PMC task which is to manage the process of handing over the BIM deliverables. The contractor submits the final BIM deliverables which are then sent over to the Supervision Consultant for technical review and submission. The BIM non-technical deliverables are reviewed along with the coordination with the end user for deliverables tacking over. The final step is the employer end user taking over the BIM deliverables.

7.2.5 Validation of proposed framework

Following the development of a framework on the PMC role in relation to the use of BIM in construction projects, the study sought to achieve validation through ten interviews. This was deemed to be necessary in order to establish how well the framework fits in real construction settings where PMC and BIM are involved. Based on their experience and expertise in the field of PMC all the respondents agreed that each of the tasks was important in ensuring effective use of BIM in construction projects. Only minor differences in views occurred among the respondents. For instance, only one of the interviewees deemed it necessary to extend the PMC role in BIM management beyond the close out stage. The other nine did not consider PMC are relevant beyond this stage and hence the proposed framework was retained without changes. In addition, one of the respondents stated that the PMC should be involved before the pre-design stage, however the other respondents did not share this view and hence, proposed framework was developed without any changes.

7.3 Conclusions

The construction industry is still characterised by poor performance relative to other industries in aspects such as client satisfaction, profitability and use of innovative technology. There is a need to minimise wastage in the construction industry through the use of lean construction approaches, integrated project delivery and technologies such as BIM which supports enhanced levels of interoperability. The use of PMC in construction projects offers beneficial outcomes in relation to clear leadership and minimisation of in-house conflicts. However, PMC may encounter challenges related to multiple and competing objectives and lack of cooperation from other professional stakeholders. The application of BIM in construction projects is crucially important in terms of overcoming challenges faced with earlier CAD developments such as 2D. While BIM adoption in the UAE is increasing lack of adequate knowledge, resources and global standardisation of the BIM standards are key barriers. There is a need to involve PMC role in BIM projects. The primary function of PMC should be BIM management. However, each phase of the project lifecycle has a specific task for PMC which should be adopted in order to ensure success in the achievement of BIM deliverables.

7.4 Research limitations

The study qualitatively examined the proposed framework for the PMC role in relation to BIM through the use of case studies. The limitation of using this method is that despite offering in-depth views, only a few respondents can take part. As a result, the extent of generalisation of the findings may be limited

Another limitation of this study was that it was limited to a relatively small sample of PMC organisations in the UAE. This can be attributed to the fact that PMC industry in the country is still at its early growth stages compared to other developed countries such as the UK where a large number of such organisations can be found. Larger samples are often necessary in terms of providing a wider range of views.

In spite of the above limitations, the study provided well-grounded empirical evidence on the approach that can be used to BIM into the PMC role at the various phases of the project lifecycle. The resultant framework was also validated with the help of industry experts with the necessary contextual knowledge.

7.5 Recommendations & Future Researches

The study has several practical implications. For one, it has developed a solid and robust framework which can be applied in the industry. Since this framework was developed with industry experts and has been validated, it is a robust framework which incorporates the PMC as a core in all of the stages starting from design stage to the final handover stage. Applying this framework across the industry can streamline the roles of the PMC and lead to efficiency as well as productivity in the Construction Industry.

Based on the limitations identified in the preceding section, the following recommendations can be proposed for further research:

- Future research can validate the proposed framework using quantitative methods. This will, in turn, allow for increased generalizability of the study findings.
- In future researchers may also seek to use a larger sample of firms. It is expected that the PMC industry in the UAE will continue to grow and hence more firms may inter the industry. As opposed to relying solely on interviewees as the main data collection method, researchers could also adopt a mixed methods approach in which case the survey strategy is combined with interviews.
- The integration of BIM into the PMC role may also vary from one country to another. As such, researchers may in future seek to engage in comparative studies, for example, a comparison of PMC roles in BIM between UAE and Saudi Arabia in the Middle East region. The comparison can also be made in relation to developed countries such as the UK with the aim of identifying gaps and best practices.
- Finally, since this research was conducted keeping in mind the traditional procurement route, further studies can focus on the other procurement routes as well.

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Appendices

Appendix A- Journal paper

BIM for Project Management Consultants

Prerequisite of integrating BIM to PMC role in UAE construction Industry

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***Abstract*— Building Information Modeling (BIM) has exhibited expansive growth and adoption within construction industry globally. With the increased complexity of construction projects the importance of key players such as Project Management Consultants (PMC) cannot be understated. This paper investigates the necessity of integrating BIM into PMC role in UAE construction industry.**

Keywords- BIM; PMC; Project Management, UAE

Introduction

The construction industry is one of the key players in the global economy; however, the industry been characterized by poor performance in comparison with other industries like manufacturing. Project Management Consultancy (PMC) constitutes one of the key stakeholders in the construction industry that can significantly influence the sector's performance through application of technology in providing their professional services [1]. By definition, PMC is a client's advisor or representative who leads, coordinates, supervises and manages all the organizations in a project to achieve the project's objectives [2] [3].

One of the technological tools that can be used by PMC to improve performance in the construction industry pertains to Building Information Modelling (BIM). Simply defined, BIM is an information production and management process that can be used to effectively manage the construction process [4]. Regarding benefits, BIM aids in the process of creating, communicating and analyzing building models. This is, in turn, assists in making the construction process more efficient, effective and interoperated [5].

The substantial benefits accrued from the use of BIM have seen it gain popularity in UAE construction industry where industry regulators from Dubai Municipality are issuing circulars mandating its use in certain projects.

As the use of BIM becomes increasingly popular in UAE, it will be necessary for PMC to adopt greater levels of use of BIM in undertaking their consultancy roles. Accordingly, this research seeks to investigate the various ways in which the BIM concept can be integrated into the role and practice of PMC in UAE. It will contribute to existing research by developing and recommending an optimum BIM management practice enhancing the PMC's role and practice in UAE construction industry.

The overall aim of this research is to develop an optimum BIM management proposal enhancing the PMC's role and practice in UAE construction industry. It achieves this aim through reviewing the construction industry performance and PMC role; reviewing the BIM evolution and practice; exploring PMC's current functions and tasks; and identifying key functions which can be best supported by BIM.

Research Methodology

Literature Review

As part of the research process, it is inevitable that the researcher will need to judge the study's findings about other people's research [6]. Accordingly, mapping and assessing the current intellectual territory in the chosen area of study through a review of literature is highly important. For this research, a literature review will be necessary for some reasons. First, it will be important to investigate and understand current issues within the construction industry especially about evolving role and practice of project management consultants. Second, it is important to familiarize with current developments in the concept of building information modeling in aspects such as its adoption by various stakeholders in the construction industry.

Data Collection / Exploratory Study

About the proposed research, there has been limited research efforts to investigate how the PMC role fits within the BIM practice. Accordingly, an exploratory research that makes use of qualitative data will be adopted. Use of qualitative data makes it possible to obtain an in-depth understanding of the variables and relationships under consideration [6]. In consistence with the choice of a qualitative research process, data that will be used in developing the proposed prototype will be collected from a combination of in-depth literature review and series of interviews with PMC experts and consultants. The use of multiple sources of information constitutes data source triangulation which has been shown to strength research through additional insights into a topic, verification, and validation of similar data and ease of recognition of inconsistencies in data sets [7].

Desktop Study

Data collected from previous stages of this research will aid in developing the proposed scenario for PMC role, duties and responsibilities towards BIM during project's life cycle in relation to UAE construction industry. A desktop study approach is adopted in identifying current issues that need to be addressed in the PMC role.

Literature background and current research limitation

The literature review process seeks to establish the research conducted and published in the area of interest. From this process, it becomes possible to not only enhance one's knowledge in the field of interest but also clarify and justify the current research questions and methodology [8]. Conventionally, the main sources of information used in the literature review include published books, reports, journal articles, conference papers, reports and published theses [9] [10] [11]. The literature review for this research focuses on two main issues: strategic issues in the construction industry and PMC role evolution; and BIM status and current practice globally and locally.

Construction Industry strategic issues and PMC role evolution

The construction industry in UAE has in the past years exhibited expansive growth. The growth is attributed to a host of factors such as high levels of government infrastructure spending; growth in the tourism sector; the emergence of Dubai as an economic hub in the Middle East region and the anticipation for Expo 2020 among others [12].

As a result of the high growth levels, the construction sector has gradually become a key driver of the economy especially in the Emirate of Dubai. The general construction industry around the world has however been characterized by poor performance in comparison with other industries like manufacturing. Specifically, a significant number of construction projects tend to be marked by extensive delays which lead to substantial time and cost overruns [13] [14]. Too many of the industry's clients are therefore dissatisfied. The situation has further been exacerbated by the growing number of mega projects which are significantly complex and difficult to manage [15].

The poor performance of the sector has prompted various initiatives meant to identify areas where improvements can be made.

One of the most popular initiatives was initiated in the UK construction industry where Sir Egan in 1998 released a report called "Rethinking Construction" [16]. Among the main highlights of the report is that the construction industry not only in the UK but also around the world is marked by high levels of waste and inefficiencies compared to other industries. Since its release, the report has paved the way for extensive research and efforts in rethinking construction, developing ways of improving performance and tackling fragmentation.

Three main areas and processes where improvement in the construction industry is necessary to have further being highlighted. First, there is need to improve productivity, quality and cost deliverables through the use of a new process of lean, value management, supply chain management, re-engineering and use of performance indicators. Second, industry stakeholders need to take full advantage of IT and other new technologies. Third, there is need to develop people and cultural mindsets to facilitate progress in the above areas [17].

Within the above perspective, project management consultants through their PMC role are one of the industry stakeholders that are instrumental towards improving the sector's performance. This can be achieved through the application of technology in providing their professional services [1]. PMC offers an effective management solution to help increase and improve the outcomes of construction projects through the consultants' skills, knowledge and experience at various stages [2] [3]. In greater detail, PMC play a major role in solving design issues, contractor coordination issues, construction issues and safety issues among others [18]. Therefore, the key reason for appointing PMC to manage a construction project is to "ensure that a client's needs, designs, specifications and relevant information are made available to and are executed as specified with due regard to cost by design team, consultants and contractors so that the client's objectives are fully met [19].

BIM status and Current Practice Globally and Locally

The BIM adoption in construction industry locally and globally is driven by calls for change in Architecture, Engineering and Construction (AEC) industry [20]. BIM significantly improved the process of delivering construction projects from inception through design, construction, and operation [21]. Adaption of BIM process and technology provides various benefits for different stakeholders through all stages of project lifecycle as noted by many [5] [21]. It is also essential to understand that BIM is not just defined as a 3D modeling; it equally involves the ability to transmit and reuse the information imbedded in it. Depending on the data fed into the model, 4D and 5D models that incorporate time and cost aspects could also be developed [22] [23] [24]. By adding other factors, more dimensions of BIM model can also be developed. It is also important to highlight that here are five aspects of collaboration and integration of BIM practice recognized as POWER (Product information sharing, Organizational roles synergy, Work process coordination-Environment for teamwork, Reference data consolidation) [25].

According to the Smart Market Report, BIM is mandated in various countries in the world such as US, UK and a range of other countries around the world. [25, 26].

In the USA, BIM adoption increased by 54 % between the 2007 and 2012 [26] while in European countries it reached 36% in 2010 [27]. In the UK, BIM adoption increased from 13% to 39% between 2010 and 2012 [28]. Meanwhile in the Middle East, it is estimated that about 10% of construction projects are making use of BIM [29]. The Scandinavian countries have also emerged as BIM leaders in the world [30, 31]. Increasing use of BIM has seen there are numerous publications, research results, and policies been developed for BIM implementation in Europe as well the other nations in the world [32]. In Asia, Singapore was the earliest BIM adaptor, and the first in the world to necessitate the BIM e-submission [33]. Notably, the BIM e-submission was mandated by the government in 2008 through the two organizations of Building and Construction Authority (BCA) and the Construction and Real Estate Network (CORNET) [32]. In New Zealand and Australia; a BIM Draft handbook was produced in 2014 to be used as a guide and a supporting document to help in the BIM Implementation to be used which [32] was introduced as “BIM as a changer” [34].

In UAE, Dubai Municipality mandated BIM for projects matching certain criteria of height and complexity. One of the main problems in implementing BIM in UAE is that there are no published and accepted BIM standards and protocols. While most clients want to implement BIM in their projects, they do not have a clear understanding of its meaning and practical implication [35]. It is reported that no more than 10% of UAE construction industry are properly aware of the full scope of BIM [36].

After reviewing the relevant resources and previous research; it is concluded that there has been limited research efforts to investigate how the PMC role fits within the current BIM practice. Accordingly, this research seeks to bridge the current gap.

Data Collection

The fieldwork of the present research comprised of two main Stages: data collection stage and analysis of the results to find out an effective integration of BIM and PMC.

Data collection stage consists two parts. The first part entails investigating the current practices for PMC role, duties and responsibilities as well as reflecting these practices on the RIBA plan of work. The second part involves exploring the current shortfall in PMC involvement in the current BIM practice. To achieve this objectives, structured interviews were conducted with representatives from some of the main PMC organizations in UAE.

Data Collection – Research Methodology

The research process is about collecting data and processing it into information [37]. This definition of research is directly applicable to this study in which case gathering insight information of current practice in the local industry of Project management consultants in UAE is deemed necessary.

There are two main reasons why such data collection is required. First; there is lack of statistical and published data pertaining to the subject of research. Second; there is a lack of standards defining bases for project management consultants practice in the region.

Studying different research methodologies, informed the need for conducting interviews instead of the questionnaire survey methodology:

Some of the key advantages of interviews are; the opportunity to explain the aim of the questions, to be able to use different data-collection techniques and availability of face to face interaction time to capture valuable and in depth information [11].

Additionally, interviews have a major advantage of receiving more qualified answers and offer an opportunity to clarify the questions not understood be respondent [38][39].

The number of well-established and accessible PMC organizations in UAE is relatively small. UAE results suggest that there are about 40 PMC organizations in UAE but only less than 20 fully specialize in offering consultancy services to medium and large construction/building projects. The relatively small number means that it could not be possible to undertake a representative study within the recommended margin of error for quantitative studies.

Design of the data collection instrument and sample considerations

Interviews are classified under three types: structured, semi-structured and unstructured [40]. The structured interviews are prepared prior the meeting, providing uniform information [11], could be prepared around questionnaire [41] and considered as useful tool when straight forward data required [41]. The unstructured interviews are mainly based on an in-mind plan which is not expressed directly as discussion would be changed based on interviewees responses [41].

Semi-structured interviews afford more room for discussion with a recording of respondent views and opinions [38] [40]. Such technique is appropriate when interviewing elite members of organizations or community [41]. In light of the aforementioned characteristics of different types of interviews; the semi-structured interviews arise as most suitable for this research for the following reasons:

- The research aims to propose a holistic proposal that covers various aspects of project management consultants’ role through different stage of project’s life cycle; hence the selected interviewees are to be in the position of director or project manager.
- This approach permits ease of comparison of responses since similar questions are posed to all interviewees.

To ensure that data was collected from the most relevant respondents, the researcher made use of purposive sampling. This sampling technique as Saunders et al. (2012) explains enhances the credibility of responses by ensuring that data is only collected from individuals who have expert knowledge regarding the field under investigation.

Interview questions design

A three-part interview structure was used in the interview protocol.

The first part of the interview involves the organizations' business status. The aim is to ensure that the core practice of the firm was within project management consultancy.

The second part of the interview questions aim to investigate current roles and responsibilities of project management consultants in each stage of projects' life cycle.

The third part of the interview aims to explore current limitations and gaps in Building Information Modeling practice. For this stage interviews have been conducted with BIM Managers in 5 PMC organizations.

Data collection results and analyses

The value of each research comes from its outcomes. The data collection approach and process need to be translated into valuable, measurable, qualified and quantified information. For the first two parts of the interview professionals from 10 organizations were interviewed in order to collect the anticipated data.

Current PMC Role in UAE Construction Industry

The following are the findings from the interviews pertaining the first two parts of interviews described above.

Only 50% of PMC companies in UAE have their core businesses as PMC only. 70% of interviewed persons were directors, and 20% were project managers. It worth mentioning that 37% of PMCs in UAE are hired at pre-design stage, while 38% are hired at design stage and 25% get hired by client at the construction stage.

The second part of interviews is the core of data collection for this research. The responses from these interviews were analyzed through content analysis. Through the content analysis method, color coding was used to highlight key roles of PMCs as provided by the interviewees at each of the three stages. The key roles and responsibilities emerging from the responses were summarized and are demonstrated in the figure 1 below.

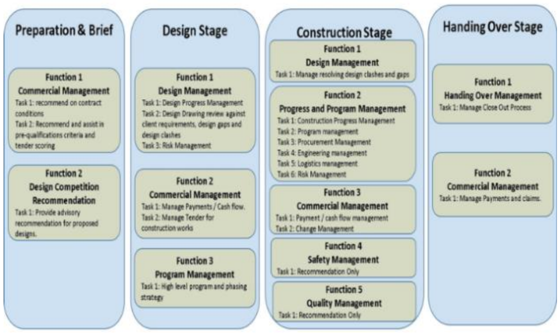

Figure 1: PMC key functions and tasks in UAE construction industry

All interviewees have emphasized on one vital statement. "PMC role associated to all functions and tasks at all stages is advisory. and their decision are not compulsory and definitely PMC do not hold technical liability".

It is important to highlight that above findings of the data collection agree with the previous findings of the literature review for this research.

PMC is "a client advisor who leads, coordinates, supervises, and manages all the organizations in the project in order to achieve the project's objectives" [2] [3] [4]. PMC only performs project management consultancy services and does not carry any construction or design works [18]. Project management consultants have been described by CIOB as "clients' advisor who leads the project" [19]. Role of project management consultants is "ensure that a client's needs, designs, specifications, and relevant information are made available" [19]. One of key advantages of PMC is to release the architect from management role which is necessary as management is not their best skill [42] [43].

PMC Role Applied to RIBA plan of work

According to the Royal Institute of Building Architects (RIBA) plan of work; project lifecycle is broken down into 8 stages starting from stage 0 Strategic Definition up to Stage 7 In-Use (Operation) stage of projects' life cycle. However, not all stages are applicable to this study as involvement of PMC and other external stakeholders such as architect and contractor are limited from Pre-Design Stage up to Handing Over stage. Moreover; the three stages of design could be grouped in one design stage.

Figure 2 summarizes the outcomes of the data collection stage and reflects the interview outcomes addressing the current role and practice for PMC in UAE and how it is applied to RIBA Plan of Work.

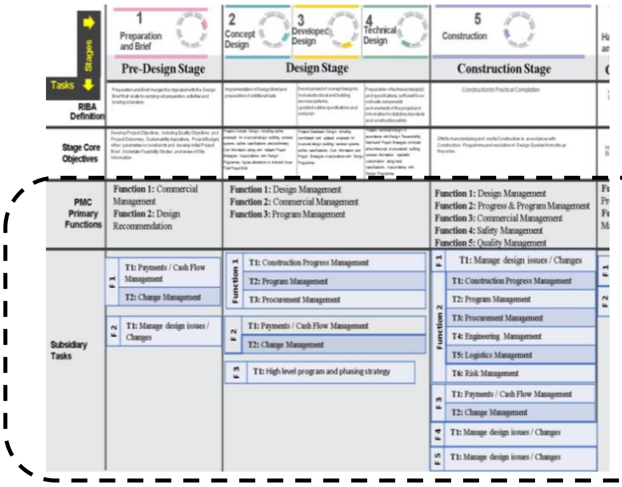

Figure 2: Applied PMC functions and tasks to RIBA plan of work.

Present gaps and limitations to PMC role in relation to BIM

50% of the interviewees agreed that they used BIM in their projects. However; they all underlined that such decisions were completely depended on the client decision and therefore BIM use depended on client requirements and BIM awareness as well as skills.

Generally; the recommended amendments to PMC contribution in BIM process at each stage of project's lifecycle was either producing some new functions, or amendment and add-ons to the current functions as explained below.

Pre-design Stage: A new function would be added at this stage related to BIM. This function can be defined as: identifying and drafting project's BIM strategy. This would be achieved by reviewing the client's BIM requirements through employer information requirements as well as providing necessary recommendation to the same. It is recommended that client would focus their requirements on what they need rather than how they need it. In addition, adding necessary BIM requirements from project delivery perspective. Hence; this could be identified as Function 3 with two subsidiary tasks.

There are as well amendments to the current function of the commercial management role which involves drafting designer's scope for BIM in line of the project BIM strategy drafted in the aforementioned function. A second task has been recommended under commercial management for reviewing BIM maturity matrix by designers' pre-qualifications. Another additional task is to review the high-level BIM Execution Plan provided within tender documents.

Design Stage: A new function is also required at this stage for effective BIM management. This function would involve subsidiary tasks of reviewing the detailed BIM execution Plan by the designer against the project BIM strategy.

There are also recommended amendments to the current functions. For commercial management function new tasks arise. First task involves drafting contractor's scope for BIM in line with the project BIM strategy drafted in the aforementioned function. The second task involves reviewing BIM maturity matrix by contractors' pre-qualifications. A third task is recommended for reviewing the high-level BIM Execution Plan provided within tender documents.

Another existing function of design management would incorporate BIM tasks by PMC by reviewing delivered BIM models against client requirements within the added data.

For the program management function, an additional task of delivering BIM deliverable in line with program of works is suggested.

Construction Stage: At this stage; again, a new function arises which involves reviewing the submitted BIM Execution Plan and to ensure that it is in line with the project BIM strategy. Meanwhile; there are current functions which would not interface by PMC BIM role. Those are the design management, safety management and quality management functions.

With regard to the current functions; several amendments were recommended. For program management function; new task arises for 4D BIM various applications by PMC. As for commercial management function; it was recommended that BIM involvement by PMC would be limited to certifying BIM related payments against deliverables.

Handing Over Stage: The last stage of the project which is also known as the close out stage, has limited involvement of BIM with the only additional task being the function of managing the handing over process. The additional task for PMC would the management of handing over process for BIM deliverable including Model handing over.

Conclusion

PMC has the potential to enhance the performance of the construction sector through the application of technology in the achievement of project objectives. In UAE, the use of BIM as one of the technologies that permits effective transmission of information among construction stakeholders is gaining popularity. However, UAE lacks published and accepted BIM standards and protocols. The use of BIM is also largely voluntarily with the only mandated use being in the Dubai Municipality for projects that match certain criteria of height and complexity. As interest in use of BIM in the country continues to grow, the study suggests the need to integrate the PMC role with BIM practice. From the study findings, it can be noted that the PMC role is not accorded equal importance in all stages of the construction process among clients in UAE. While some clients hire PMCs at the pre-design stage, others do so only at the design and construction stages. An evaluation of the RIBA plan of work in the study also suggests that not all stages and functions are applicable to the PMC role in aspects such as design management, safety management and quality management. New roles related to PMC at the various stages of RIBA plan of work are also suggested including identifying and drafting project's BIM strategy, reviewing BIM maturity matrix by designer's pre-qualifications and against the project BIM strategy, drafting contractor's scope for BIM and a review of the submitted BIM execution plan among others.

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Appendix B- Conference paper

BIM Standards Around The World

A Review of BIM Standards in the Global AEC Industry and BIM Roles of Project Stakeholders

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This paper investigates the nature of national BIM standards amoung various countries and examine the presence of standards that clarify the BIM roles of project stakeholders such as project management consultant (PMC) at the various stages of the construction project lifecycle, including inception, design and construction. A research has been conducted which case BIM studies from UK, Norway, Finland, US, Canada, Singapore and Australia were reviewed. The study indicates that current BIM standards have mainly focused on explaining the model standards and BIM requirements. There are only a few national standards, such as the case of Singapore, which highlight the BIM objectives at each stage of the construction process, the project stakeholders that should be involved, and the deliverables. The specific roles of the various project stakeholders for each objective are not adequately clarified and hence likely to vary from one project and organization to another.

Keywords- BIM, standards/guidelines, project stakeholders, roles

Introduction

The construction industry has in the recent times being characterised by resource scarcity, sustainability challenges, increasing complexity of designs and stricter regulation for sustainability and resource efficiency [1]. Such challenges have collectively enhanced the level of interest in new and innovative ways in which operations in the architecture, engineering and construction (AEC) industry can be enhanced. Within this context, Building Information Modelling (BIM) has increasingly been seen as a potentially effective way of dealing with these challenges. BIM as a process involves developing and using of computer software model for purposes of simulating the planning, designing, construction and operation of a facility. The resulting building information model is a data-rich, object-oriented and parametric digital representation of the construction project [2]. Data in the model can be extracted and analyzed in order to generate information that facilitate decision making as well as improved delivery of the complete project [3].

BIM constitutes a subset of computer-aided design software but makes use of processes that are significantly different from CAD. The advent of CAD in the late 1960s moved the manual pen and ink process to the computer thus making it possible to produce 2D drawings that were easier to manipulate, modify and retrieve [4]. In the late 1970s and early 1980s building information modeling based on 3D solid modelling was developed replacing 2D CAD for design development. Over the years BIM has seen further enhancements to include a time/schedule model (4D), cost model (5D) operation model (6D), sustainability model (7D) among others depending on the available information [5] [6].

From a design perspective BIM helps in presenting the elements of structure such as beams and columns as objects in digital models. Such representation significantly increases visualisation and hence the ability to improve design [7]. As BIM becomes increasingly implemented around the world, its applications have also gone beyond the improvement of design. BIM can be applied in the production, communication and analysis of building models; intelligent simulation of architecture; and improvement of the delivery process through provision of consistent and non-redundant data [8]. There is a general consensus in existing studies that the entire building life cycle, from conception to demolition, can be covered by BIM applications [9].

Uses and benefits of BIM

BIM offers a range of benefits to stakeholders in the AEC industry. It serves as an effective tool for data management during the entire project lifecycle by facilitating fast and easy access to information that is stored in a single centralised database [10]. The effective management of data further contributes positively to planning and scheduling of facilities through improved communication [12] [13]. Effective sharing of information through BIM also results into elimination of redundant efforts and hence more time is focused on the improvement of design and expedition of the construction process. Prior research has within this context indicated that ‘waste and inefficiency’ constitute a huge problem in the construction industry. For example, delays, errors and inefficiencies in the US construction industry have been found to account for $200 billion of the $650 billion that is spent on construction annually [14].

BIM also offers simulation benefits. It can not only simulate 3D, 4D and 5D building models but also a range of other operations, such as sunlight, emergency evacuation and heat transfer [15] [16]. BIM further provides a platform through which integrated management in aspects such as feasibility studies, objective design and planning and supply can be undertaken in an efficient way [17].

Statistically, the use of BIM in construction projects has been shown to lower costs by 33%; increase speed of delivery by 50%; contribute to sustainability by lowering green house gas emissions by 50%; and improve exports of construction products by 50%. A survey by McGrawhill Construction also identified benefits that key stakeholders in the AEC derive from the use of BIM (see figure 1).

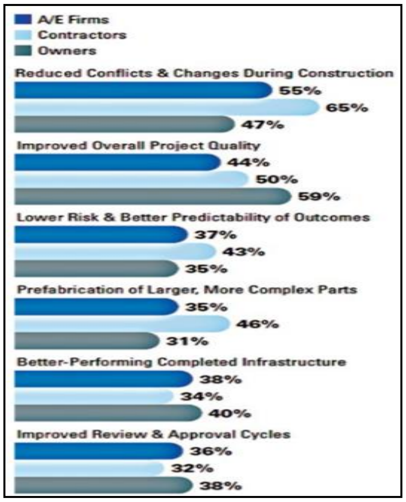

Figure 1: Benefits of BIM to stakeholders [18]

Current challenges in BIM adoption and execution

Adoption of BIM has been on an upward trend around the world. In developed countries such as UK and the USA the adoption rate by both the government and private sector has been high. A National BIM Report for 2016 in the UK by the National Building Specifications (NBS) for instance revealed that more than half of the professionals (54%) in the AEC industry were using BIM on at least some of their projects while another 42% were aware of it [12]. In developing countries such as Malaysia; BIM has been well received but the adoption rate has been relatively slow [13] [14]. Adoption of BIM at the global level is affected by the lack of standardisation of the BIM standards. In order to facilitate the collaboration between the stakeholders inside and outside of the BIM environment, it is important that standards for information exchange are agreed upon.

Standards are within the above context the guidelines, protocols and mandatory regulations that underlie the use of BIM. In the absence of standardised BIM guidelines it becomes difficult to agree on the quality of information to be used thus further affecting the use and reuse of the information among the partners. Furthermore, lack of standardised BIM guidelines negatively affects the extent to which building products and process are interchangeable. This in turn impacts the identification of products, processes and parameters that reduce inconsistency and the associated high costs [15].

Majority of existing studies on BIM have primarily focused on BIM deliverables and requirements [16][17]. In the process, an investigation of the extent to which BIM is sufficiently standardised has been not as much of coverage. Further, existing studies are yet to examine whether the roles of the different project stakeholders such as Project Management Consultants (PMC), contractors, architects, engineers and construction managers are clarified for each of the project lifecycle stages (i.e. plan, design and construction) in BIM.

This study seeks to fill these gaps through the following objectives:

- To explore the various BIM standards adopted around the world in the AEC industry
- To examine the clarity of roles of project stakeholders in each stages of project lifecycle in BIM standards

Review Approach: Research Methodology

To garner the data required in achieving the objectives the study made of secondary data research. By definition, secondary research involves the collation and synthesis of already existing materials such as journals, textbooks, industry documents, periodicals and internet articles among others [18]. Several factors necessitated the use of secondary data. Firstly, the study required collection of BIM standards in several countries across regions such as North America, Europe, Middle East and Asia. Second, a significant amount of information on BIM standards has been comprehensively compiled in publicly available documents by relevant organisations such as the National BIM Standards (NBIMS-US) and British Standards Institute (BSI) in the UK. The availability of the BIM standards information makes the secondary research the optimal method to ensure a comprehensive data collection approach. Lastly, secondary research is appropriate for studies requiring national or international comparisons [19].

In order to ensure reliability of the data, only BMI standards from countries where the practice is well developed are included. Such countries include Canada, Finland, Australia, Norway, UK and USA. Content analysis was used to identify the key BMI standards as well as facilitate the comparison with relation to inclusion of roles of project stakeholders in each of the stages of the lifecycle.

Findings

The following part of this paper will cover an overview of BIM standards around the world:

United Kingdom

BIM standards in the UK have been published by various organisations including the British Standards Institution (BSI), the BIM Task Group, AEC-UK and the Construction Industry Council [21]. BIM standards in the country are classified based on the maturity levels (see figure 1). At level 1, the BIM standards involve the collaborative production of 2D and 3D CAD information and provision of directions pertaining to the management of the design process. At level 2 the standards help in the achievement of BIM compliance on the use of file-based electronic information. Currently, the majority of stakeholders in the industry seek to achieve the second level BIM maturity. At Level 3 BIM maturity, the standards explain the integration of BIM and life cycle information. Attaining this level of maturity constitutes a long term objective for most stakeholders the AEC industry [22]. Table 1 provides a summary of the main standards in the UK.

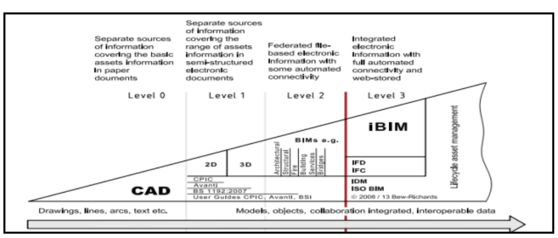

Figure 2: BIM Maturity Levels

- PAS_1192_2_2013 Information management for capital/delivery phase using BIM:

This PAS constitutes an extension of BS 1192:2007 which provides information in regard to code of practice for the collaborative production of AEC information. It mainly focuses on project delivery phase which involves the accumulation of graphical and non-graphical data/documents for use in design and construction activities. Among the main stakeholders that find this PAS useful include individuals that are in charge of procuring, designing, construction, delivery and operating of building facilities.

The contents in this PAS are in the form of requirements for the stakeholders. The requirements are specified based on four stages of information delivery including procurement, post contract-award, mobilisation and production. Specific roles of stakeholders based on project lifecycle stages are not included.

- PAS_1192_3_2014 Information management for operational phase of assets using BIM:

This specification is similar to PAS 1192_2. The main difference is that it focuses on the operational phase of the facility as opposed to the capital/delivery phase. It is therefore relevant for project stakeholders responsible for operating and maintaining assets.

The requirements of PAS 1192_3 revolve around the transfer of data from the project information model (PIM) to asset information model (AIM) in the operation phase.

PAS 1192-3 broadly sets out roles by mentioning that the responsibility for information management should be set out in the contract between the asset owner and the operator/maintainer in the operation phase.

- BS_1192_4_2014 Collaborative production of information – Employer's information exchange requirements using constructions operations building information exchange (COBie):

This standard provides a schema in the form of a multi-page spreadsheet through which stakeholders such as suppliers and designers can create structured information and share it with the employer for purposes of assessing and using. One of the main benefits is that information in COBie can be reviewed and validated for compliance and completeness. The information covers aspects such as overall asset management, support for business questions and regulatory responsibilities.

BS_1192_4states in a general manner that during the briefing and operational phases it is the employer who should provide information while stakeholders on the supplier side should provide information in the design and construction phases.

- BS_8536_1_2015 Code of practice for facilities management:

The standard offers guidelines and recommendations regarding the information and data that project stakeholders need in order to enhance optimum operability and performance of the facility. As such, the standard is limited to the operational phase of the project life cycle. It can however be noted that information offered in this standard is still important in the design and construction phases where issues to operability are taken into consideration.

This standard articulates the roles of various project stakeholders although at the general level as opposed to roles at each phase of the project. The owner is required to determine the composition of the design and construction team and emphasise on collaborative working. The owner's representative (PMC) is on the other required to liaise with the design and construction team to ensure the required project outcomes and operational performance are taken into consideration. General roles for the operations team and facility manager are also described.

- PAS_1192_5_2015 Specification for security-minded building information modelling:

The specification recognition that BIM information may be subject to security threats. Accordingly, it offers and awareness of the security measures that project stakeholders making use of BIM should undertake in order to ensure that information pertaining to the project, system and asset remains well protected and managed. Only the role of the built asset security manager is specified and ranges from providing a holistic view of security issues to offering guidance on addressing the security issues. The roles of other project stakeholders at different phases of the project life cycle are not clearly articulated.

- 1192_2007_A2_2016 Collaborative production of AEC information- code of practice:

This standard considers collaboration among stakeholders in construction projects as crucial to efficient delivery of facilities. The standard is mainly applicable in construction project documentation and allows for to work efficiently through standard data that solves problems of data reproduction.

Norway

Currently, Norway BIM standards are published by Statsbygg (A government department) and the Norway Association of Construction. The BIM manual offered by Statsbygg mainly focuses on defining the requirement that apply to the BIM deliverables. At the basic level two sets of requirements are identified: The open BIM deliverable and BIM objectives. In brief, the open BIM deliverable requires that a digital 3D BIM that is based on object-based design and makes use of open BIM standards be the main deliverable.

The BIM objective on the other hand specifies that the BIM shall be modelled for the specific BIM objectives that are specified in the project under consideration [23]. An additional 13 domain specific requirements are also issues as part of the BIM standards (See Table 2). Currently, all Statsbygg projects make use of open BIM principles. Attention while using BIM in the country is mainly given to the environmental impact of infrastructure and the lifecycle costs.

- Architectural modelling

This specification recognises that an effective architectural model should contain other domains in areas such as structural elements and electrical and mechanical equipment. Accordingly, it offers guidelines on components (e.g. generic and super structure) that should be included in order to ensure an interdisciplinary architectural model. No project stakeholder roles are specified.

- Landscape architectural modelling

In order to ensure ease of visualisation, this specification provides recommendations on landscaping elements. It explains the need for geometry elements of landscaping to be exported to IFC with the help of CAD systems and also recommends the use of open formats such as LandXML and CityGML for landscaping.

- Interior design modelling

This specification offers generic requirements for inclusion of information on interior design components such as furniture, fixtures and equipment (FF&E) into BIM. It emphasises the importance of the project team agreeing upon the information but does not highlight specific roles

- Geotechnical engineering modelling

Development of this specification is still ongoing. Nonetheless, the specification highlights to project stakeholders the risk of use of architectural tools that fail to support other geotechnical engineering processes. It thus supports the need for interoperability through use of a construction site BIM that corresponds with the structural BIM thus making the transfer of information easier.

- Structural engineering modelling

This specification covers the requirements for load-bearing elements such as concrete and steel structures and non-load-bearing concrete structures. It highlights the role of the structural designer as one that involves the production of both a design and analysis model that focuses on ease of coordination and improved costing.

- Mechanical engineering modelling

The specification provides details for modelling requirements in relation to mechanical engineering. It thus covers mechanical aspects of the building process such as plumbing, fire protection, heating and energy control. Besides an explanation of the modelling requirements the specification does not detail out the specific roles of the mechanical engineer and other stakeholders.

- Electrical and communications engineering modelling

This specification as the name suggests is limited to modelling aspects of electrical and communication aspects of the building process. It offers modelling requirements for the facility's electrical and communication support systems in aspects such as technical space and geometry. Roles and responsibilities of relevant project stakeholders are not defined.

- Acoustical engineering modelling

In this specification, the modelling requirements for acoustic properties for a range of building elements such as constructions and installations are explained. It also emphasises the importance of communicating acoustics conditions to the design team in the BIM. The acoustic engineering is recognised as playing an important role in providing relevant data but roles of other stakeholders are overlooked..

- Fire safety engineering modelling

This specification sets out the fire safety conditions that the safety engineer needs to include in the BIM. The overall goal is to ensure that building projects that utilise BIM have adequate protection to fire and have a layout and space planning that allow for efficient evacuation.

- Other design and engineering modelling

The specification recognises that the process of modelling entails a wide range of special disciplines that may differ from one project to another such as kitchen and laundry in hotels and hospitals. Accordingly, it emphasises the need to include such disciplines as part of the BIM information.

- BIM construction and as built requirements

BIM in Norway is currently limited with respect to the construction phase. However, this specification indicates that contractors are free to use the BIM as they choose. It also explains a few general roles of the contractors which include receiving and using the finalised generic design-BIM, reporting changes to client and design team and updating the native BIM.

- BIM for facility management and operations

This standard is also in the development process. It explains the need for transforming the "as built" BIM to the facilities management and operations (FM&O) BIM for the operations phase of the facility.

- BIM for decommissioning and disposal

Specific requirements for this standard are not stated. However, it mentions that BIM may be used in extracting relevant information at the decommissioning and disposal phase which can be relevant in handling of reuse and waste fractions.

Finland

Finland has a long tradition in the use of BIM. At present four maturity levels have been defined [24]. BIM level 1 and 2 are already in progress. At level 1 the main focus is on data management for document based structures, 2D and 3D documents while level 2 maturity involves visualising information in combined models. Level 3 and 4 are future maturities in which information is expected to support owner's processes and life cycle management and also be linked with the built environment.

The Finnish BIM standards have been put forward in the form of requirements that must be attained by stakeholders in the AEC industry. The current standards can be found in the publication series "Common BIM Requirements 2012" which articulates 12 areas that are relevant to procurement and construction [25] (see table 3). It can however be noted that there are relatively low levels of standardisation of BIM in Finland. A large number of construction firms have been writing their own detailed requirements and best and also the majority of large consulting firms have their own BIM groups [26].

- General BIM requirements

This general specification outlines the basic principles, requirements, concepts and targets for BIM in projects. It clarifies that it is the role of the BIM coordinator to apply the targets as well as supervise the use of the model.

- Inventory models

This specification provides a description of requirements for building site modelling. It covers inventory models and emphasises the need to use reliable and accurate sources of data that make implementation of plans easier.

- Architectural design

This specification explains that the architect BIM is mandatory in all the design phases and specifies the requirements in each of these phases. No specific roles of project stakeholders are included

- HVAC + EA Design

This part focuses on building services (BS) design task. It specifies the contents for the BS system model in terms of basic prerequisites for the use and maintenance in the life cycle of the building. Although it provides information content and geometry in each of the phases it fails to specify the roles of project stakeholders

- Structural engineering

The part breaks down the requirements for structural engineering process into a list of BIM tasks. In order to enhance collaboration this specification takes into account the needs of other design team parties. This in turn makes the requirements easier to adopt

- Quality assessment

The specification focuses mainly on information producers mainly designers. It explains that these information producers should ensure that the contents of information should be appropriate and reliable in order enhance viability of BIM. Checklists

- Quantity takeoff

In this part the essential BIM requirements and guidelines for use in quantity take-off are described. It highlights that the requirements are relevant for owners, designers, contractors and product fabricators. It advocates for a shift from manual drawings to computer-assisted measurements for quantity take-off

- Visualisation

In the visualisation part the documents highlights the importance of using technical illustration in BIM as opposed to the traditional photo-like rendering visualisation. It indicates that the technical illustrated is to be used by the design team, client and project manager to facilitate easier comparison between different design alternatives and improve communication. However, the roles of these stakeholders are not included.

- HVAC analysis

HVAC analysis provides graphical illustrations of lighting calculation and lighting analysis. In the process it also highlights the possibilities brought into BS analysis by modelling. Relevant stakeholders and their roles in HVAC analysis are not clearly highlighted

- Energy analysis

In a bid to contribute towards sustainable buildings and infrastructure this standard emphasises the importance of energy efficiency management. The requirements for ensuring energy efficiency in BIM are also provided

- Management of BIM project

This specification recognises the importance of using BIM from the client's point of view. Accordingly, it describes the general project management tasks that should be undertaken in order to meet client demands. Planning, implementation and control measures during the project process are also included but specific roles of project stakeholders are missing

- Use and maintenance of building

This part provides a description of the requirements for use of BIM in the use and maintenance phase of the lifecycle. The requirements are in the form of IFC based data transfer as well as other popular transfer methods such as COBie. The benefits of using BIM in facility services processes are also articulated but key roles of relevant stakeholders in the use phase are left out

- Construction requirements

BIM requirements for the construction phase are explained in this final part. The requirements are meant to be agreed between the project stakeholders on a project basis. The main roles of the contractor at this stage pertain to the delivery of information on adjustments for the as-built model to the client

USA

The US BIM Standard has been developed as an initiative of the BuildingSMART alliance which is a council of the National Institute of Building Sciences (NIBS). In 2012 NIBS released the Ntional Building Information Modelling Standard- version 2 (NBIMS-v2) which seeks to advance the art and science of the entire lifecycle of the built environment by providing a means through which electronic object data can be organised and classified. Among the groups that the standards are targeted include software developers and vendors, design, engineering, construction and operations professionals. The specific BIM standards in the US fall under four categories: construction operations building information exchange (COBie), design to spatial program validation, design to building energy analysis and design to quantity takeoff for cost estimating [27].

A focus on defining requirements is also evident in the US. For example, available BIM documents detail out the requirements for file sharing, quality planning, quality assurance and quality control. Unlike BIM standards in other countries, there is a separate BIM manual for owners in the United States. The manual also explains the various team roles and responsibilities that the owner should be aware of. Notably, the PMC role is included in which case it is recommended that for large and more complex projects there is need for the owner to designate an owner's BIM representative. Among the roles of this representative include representing the owner's requirement and communicating them effectively to other stakeholders [27]. A separate guide also exists for architects and engineers. Collectively, the manuals mainly focus on explaining the requirements and usage of the BIM guidelines and standards. Although the roles of some of the project stakeholders are highlighted they are not sufficiently clarified based on project life cycle stages

Canada

In Canada, BIM guidelines and standards are published by a variety of organisations with the main ones being buildingSMART Canada, Canada BIM Council and Institute for BIM in Canada (IBC).Unlike the UK and USA BIM in Canada is relatively young with key institutions such as IBC being established in 2014. Adoption rates are still relatively low with some provinces such as Canada being marked by 31% adoption rate. Barriers to adoption among non-adopters have been identified and include the lack of demand by clients and the supply chain and high cost of software, training and infrastructure [28].

A further evaluation of the standards indicated that little attention has been accorded to specific roles that project stakeholders should perform at the different stages of the project lifecycle. Only roles and responsibilities related to the BIM execution have been taken into account (see figure 2). The main areas of focus have been guidelines on the benefits of BIM for owners, project execution plan toolkits, contract language, practice manual for BIM, collaborative BIM working, interoperability and data segregation [28] [29].

	Strategic						Management				Production	
Role	Corporate Objectives	Research	Process + Workflow	Standards	Implementation	Training	Execution Plan	Model Audit	Model Co-ordination	Content Creation	Modelling	Drawings Production
BIM Manager	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N
Coordinator	N	N	N	N	N	Y	Y	Y	Y	Y	Y	N
Modeller	N	N	N	N	N	N	N	N	N	Y	Y	Y

Figure 2: Roles and responsibilities for BIM execution in Canada

Attempts to achieve interoperability at the international level are also evident in Canada. For example, BIM standards and protocols used in Canada were adapted from protocols used by AEC UK. The rationale behind adopted of the framework used in the UK is that BIM enabled technologies are consistently being used in the same way around the world (← What does it mean that BIM enabled technologies are consistently being used in the same way around the world? The reader may need a rationale for researching 'standards' then) and that it was prudent to make use of already existing standards as opposed to investing time to reinvent and create unique standards for Canada. Adapting of the BIM standards in Canada is also done with reference to US BIM standards published by NBIMS US V2 [28].

Australia

In Australia the development and use of BIM standards is largely coordinated by NATSPEC. The organisation has compiled a list of both local and international standards that players in the industry should use in the construction process [30].

- Australia and New Zealand Revit Standards (ANZRS)

The standard is designed for use by Autodesk Revit users. It allows them to define the project content and data and hence an enhanced ease of communication with consultants

- AEC (UK) BIM Standard

This standard is designed for use by clients in the design and construction stages. It is a generic document that is adapted from the UK BS1192:2007 BIM protocol. It seeks to provide information on techniques and concepts that architectural engineers can use at the design stage while utilising BIM technology. The roles of other professionals such as Quantity Surveyors, Contractors and Facility Managers are not specified

- US National CAD standard, ISO 13567 and AS 1100

This standard is adapted from the National CAD standard used in the United States. It provides a layering system for information used in the construction process. The classification of electronic building design data in this standard helps in streamlining and simplifying information and communication among key project stakeholders such as owners, designers and construction teams. Although the standard is applicable from project development stage to use of facility stage specific roles for various users are not defined

- VA BIM Guide 'Trade colours for Clash detection

This standard provides guidelines for clash detection as one of the BIM applications. The guidelines are meant to identify all clash processes so that they can be resolved before commencement of the construction process. Specific responsibilities of design/construction team and BIM manager are explained. However, the PMC role is not specified

- National Guidelines for Digital Modelling

This standard provides basic information for BIM users in relation to digital model creation and development. It also offers guidelines on how to engage in simulation and performance measurement. Although the PMC role is not articulated the standard emphasises that one of the reasons for models is to enhance information sharing between consultants and other stakeholders

- Masterformat, Coordinated Building Information (CBI), Uniclass Table J

The standards provide guidelines for developing a work results classification system. It recognises that the construction industry requires significant collaborative effort. The standard is therefore geared towards interoperability by ensuring that stakeholders can create, communicate and find relevant building information when needed.

Singapore

Spring Singapore is the country's national standards authority which coordinates the national standardisation program as well as Singapore's participation in international standardisation efforts. The Building and Construction Authority (BCA) have also been offering guidelines as such as the Singapore BIM Guide Version 1.0 published in 2012 and version 2 published in 2013. Currently, there are a total of seven main standards that explains the requirements for modelling and collaboration. They include individual discipline modelling, cross-disciplinary model coordination, model & documentation production, data security and saving and quality assurance and control, Workflow of design-build projects and [32]. Following is a summary of the key aspects of each standard/guideline.

- Individual Discipline Modelling

This standard provides information on procedures to be undertaken during modelling of BIM elements. It also provides guidelines for use in architectural and structural modelling for purposes of regulatory submission. It also emphasises the need for diving model into separate levels based on project size and phase as well as revising the model at the various project stages

- Cross-disciplinary model coordination

This standard provides guidelines on how the various stakeholders can achieve interoperability. It emphasises the need for sharing models and coordinating them with inter-disciplinary parties. Figure 3 provides an illustration of the collaboration required in the standard at various phases of the project

- Model & Documentation Production

This standard projects that conflicts may occur between 2D drawing contract documents and BIM model. In such a case contract documents take precedence but efforts should be made to reduce discrepancies through generation of 2D drawings from the BIM model and agreement on BIM exchange formats and documentation

- Data security & saving

The standard focuses on BIM security issues. It urges BIM users to establish a data security protocol for purposes of preventing data corruption, misuse or deliberate damage

- Quality assurance and quality control

The standard recognises the need for a quality assurance plan as a way of maintaining accuracy of the BIM data. It indicates that an effective quality assurance plan should include modelling guidelines, dataset validation and inference checks

- Workflow of design-build projects

This standard outlines the various aspects that should be taken into consideration when producing a workflow of design-build projects. These include aspects such as establishing a BIM execution plan and incorporation of predefined project requirements

- Workflow of design-bid build projects

While taking into consideration the traditional design-bid-build delivery model, this standard describes generation of construction model by the main contractor. It includes activities for pre-tender stage and construction stage

	Employer	Architect	Consulting Engineers	Contractor / Quantity Surveyor
Conceptual Design	Provide requirements related to form, function, cost and schedule	Begin design intent model with massing concepts with site considerations	Provide feedback on initial building performance goals and requirements	Provide feedback on initial building cost, schedule, and constructability *
Schematic Design	Provide design review and to further refine design requirements	Refine Design Model with new input from Employer, Consulting Engineers, and Construction Manager	Provide schematic modelling, analysis and system iterations as Design Model continues to develop	Provide design review and continued feedback on cost, schedule and constructability *
Detailed Design	Design reviews. Final approval of project design and metrics	Continue to refine Design Model. Introduce consultants models and perform model coordination Finalize Design model, Tender Documents and Specifications, Regulatory Code Compliance	Create Discipline-specific Design Models and Analyses Finalize Discipline specific Design Models, Tender Documents and Specifications, Code Compliance	Create Construction Model for simulation, coordination, estimates, and schedule * Enhance Construction Model and perform final estimate & construction schedule, Manage bid process
Construction	Monitor construction and give input to construction changes and issue	Respond to construction RFI's Perform contract administration, update Design Model with changes	Respond to construction RFI's and update Discipline specific Design Models, field conditions, and commissioning	Manage construction with subcontractors and suppliers, inform changes to Design Model
As-Built		Verify As-built model	Verify As-built model	Prepare As-built model
Facility Management	Engage Architect and Facilities Group for handing over	Coordinate information exchange through model to Facilities Group	Prepare handover documentation	

Figure 4: Cross-disciplinary model coordination in BIM in Singapore

Unlike other country standards, the Singaporean BIM standards clarify the roles for consultants and contractors. The lead consultant is for instance tasked with the role of facilitating the definition and implementation of BIM execution plan, BIM goals and uses. The contractor is on the other hand required to study tender documents and coordinate with design contractors and sub-contractors among other roles [32]. It can however be noted that these roles are undertaken at the team level. Organizational level roles and responsibilities are yet to be clarified. In specific, the BIM guidelines identify a list of 28 BIM project objectives that should be completed from the conceptual to facility management stages of a construction project. It then provides an objective and responsibility matrix identifying the project members that should be involved in fulfilling the objective. Although a range of stakeholders such as architects, structural engineers, mechanical engineers, contractors and consultants are identified their specific roles are not clarified (see figure 5) [32].

BIM Project Objective	BIM Manager	Project members involved in fulfilling the objective A – model author; U – model users							
		Arc	Str	MEP	QS	Con	RS	FM	Others
Conceptual Design *Building massing studies or other forms of data representation with indicative dimensions, area, volume, location and orientation*									
1. All project members appointed at this stage to agree on needs, objectives, process and outcomes of the project. **Suggested Deliverable** • **BIM Execution Plan agreed and signed by related parties**									
2. Create site BIM models for master plan site study and feasibility analysis. - Site Analysis									

Figure 4: Extract of the Singapore BIM objective and responsibility matrix

Discussion

The review of BIM standards from various world regions in the preceding section indicates considerable efforts towards developing the standards in order to respond to the evolving industry demands. For owners it is evident that current BIM standards around the world are drafted to minimise operation and maintenance costs and the renovation costs. BIM also takes into consideration the needs of contractors who have to manage larger and more complex projects while ensuring maximum efficiency and low costs. For designers, the various BIM have been developed to respond to increased pressure to produce innovative and cost effective designs. The standards are thus consistent with the BIM benefits that have been identified in research literature [6] [7].

The UK and the US have some of the most developed BIM standards, adopted by BIM organisations in other countries such as Canada and Australia as part of their BIM framework. Arguably, cross-country adaptations can help in the advancement of standardisation of BIM at the international level. In some countries standardisation of BIM at the national level is yet to be achieved. This is for instance evident in Finland where most of the large organisations have their own BIM guidelines. It should be noted that governments in the countries that have been reviewed have pioneered the use of BIM standards in the construction industry, whereby BIM standards have spread from governmental level to the private sector. However, barriers related to cost of implementation and lack of demand have slowed down the adoption of BIM [28, 33]. There is therefore need to educate stakeholders about the ability of BIM deliverables to offer benefits exceeding cost of implementation.

All the reviewed national standards have mainly focused on explaining the model standards and BIM requirements and deliverables. It is only in the case of Canada and Singapore where efforts have been made to explain the roles that different project stakeholders should perform in relation to project execution using BIM. Even in these two cases, a narrow approach has been used in which case only a few stakeholders (e.g. project manager, consultant and coordinator) have been taken into account. The roles identified are also at the team level as opposed to the organization level.

In the case of Singapore, which has identified BIM objectives at each stage of the construction process, a range of deliverables have been identified. However, it is the role of the BIM manager to identify which project stakeholders are supposed to be involved in such delivery [31]. The lack of clarity increases the chance that roles played by the various stakeholders are likely to differ from one organization to another. In order to ensure more efficient application of BIM in construction projects it is necessary that this area be addressed.

Despite the trend towards cross-country adoption of BIM standards, significant geographical differences are still evident. As industry stakeholders seek to achieve BIM standardization at the international level, BIM managers who seek to incorporate the role of PMC should carefully review the standards and establish areas where the PMC role is best suited. Some BIM functions can be incorporated directly into PMC roles while others require adjustment.

Some of the investigated BIM guidelines recognize the potential conflicts that arise during the transition from 2D drawing based contracts and BIM. In such case, it is required that the original contract structure remains. For AEC firms adopting BIM, the standards can still update the original work schedule and plans to better make use of the information model. Importantly, with the adoption of BIM new roles in the AEC industry are also emerging. Examples include data security managers, design coordination manager, BIM lead consultants and BIM directors.

Conclusion

The use of BIM in the AEC industry is increasing in various parts of the world. Its effective use is likely to provide benefits in aspects such as planning and scheduling, ease of communication and coordination with the various stakeholders and elimination of redundant efforts. The overall outcome is reduction in waste and inefficiencies that have for long affected the performance of the construction sector. In developing countries high levels of adoption has however been hindered by the initial high costs, lack of skills in implementation and lack of enhanced standardisation of the guidelines at the national levels. In terms of roles and responsibilities, this analysis indicates that there has been inadequate focus in this area. The majority of BIM standards have mainly focused on explaining the model standards and BIM guidelines. The Singapore guidelines can be singled out for explaining the various project stakeholders that should be involved in delivering specific BIM objectives at various construction stages. New roles related to BIM such as data security managers and BIM coordinators and consultants are also identified. However, the actual roles of these stakeholders are not well clarified. It is suggested that there is need to for AEC industry to clarify roles of the project stakeholders a BIM environment in order to ensure smooth implementation.

Conclusion needs a bit more way forward analysis results based on your above discussions. Conclusion here is rather general and without any valuable addition in terms of added knowledge. You should come up with some conclusive remarks and recommendations based on benchmarking each (discussions).

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Appendix C - Interview Transcripts

Interview A Transcript

Interview 1

Position: Project Director

Q.1. How you describe the core business of your organisation?

Mace International operates as a Project Management Consultants in the region of United Arab Emirates. We are acting as a professional client advisor and representative.

Q.2. What is your position within your organisation?

I am a project Director

Q.3. For how long your company has been practising as project management consultants?

In this region and inside UAE we have been available for nearly 20 years

Q.4. What is the average percentage for projects adapting BIM within overall running projects of your organisations' portfolio?

Most of our project involves BIM practice although they could vary in minimal uses, single use or even wide uses within the project. It is important to note that BIM uses in the local construction industry is subject to client decision. Although we as a PMC would request from designers and contractors to utilize BIM; yet it is challenging in absence of client desire which will lead to no contractual obligation.

Part two: of the interview questions was investigating current roles and responsibilities for project management consultants at each stage of the projects' life cycle. Accordingly, the following questions were asked of the interviewees:

Q.5. How do you describe stages of a project where your company services are usually provided?

While the main stages of construction project where we as a PMC could provide our services are mainly the following four stages: pre-design stage, design stage, execution stage and finally the handing over stage. It never happened that we participated in the operation stage afterword.

Q.6. At what stage usually project management consultants are hired by clients?

While ideally we should be appointed at predesign stage as we would serve the client in designer selection and preparation of contractual documentations; unfortunately sometimes we got appointed at later stage. Mostly at the end of the design write before tender stage for the construction works.

Q.7. What is the role of the project management consultant at the pre-design stage?

There are various of services we can provide to our client at pre-design stage. Ideally we would help them in the designer selection criteria and nominating qualified designers. Certainly we would be involved in the commercial side as well such as drafting contracts conditions. We also start at this stage the risk management which is about generating a list of potential risk for the project and evaluation probability and impact for each one of them while providing recommendation to mitigate the risks. Moreover we are recommending on procurements strategy for the project.

Q.8. How do you describe project management consultants' roles and responsibilities at design stage of project's life cycle?

Typically we shall overlook the design development and, making sure it is ongoing within the time frame and in line with client requirements. Of course, we also have mange the commercial side for the design if there are any design changes. Also we should manage risk which is actually starts from earlier stages at pre-design stage. Meanwhile for construction stage preparation; we take the lead in managing preparation for tender documents and prequalification for contractors participating in the tender

Q.9. What are the roles of project management consultant at execution stage?

This stage is the stage where we would have the widest range of services. For start we manage the design at this stage. Although the design is completed before commencement of the construction yet there is the engineering stage by the contractor where we have to make sure the smooth production of engineering drawing. Certainly there will be design gaps and design coordination issues which we are managing and making sure it will not affect the project.

At construction stage the biggest role we have is managing the progress and the program. It involves construction progress management, program management, procurement management, engineering management, logistics management and for sure risk management.

Then comes the commercial management as we manage the cash flow of the project and certifying payments for contractors and consultants. Also, we are managing changes if there are any.

In addition to the above we manage the safety on high level as we do not hold liability for the safety.

Finally we manage the quality but again on high level as advisory role only as we have no liability for quality.

Q.10. Should project management consultants be involved during the project handover stage and what would be their role?

Yes. Our role for handing over stage will be managing the close out process. Also, commercial management as all claims and variation must be closed by the end of the project

Q.11. Should project management consultants be involved during the operation stage of the project lifecycle?

No

Interview 2

Position: Deputy Project Manager

Q.1. How you describe the core business of your organisation?

CH2M Hill operates as a Project Management Consultants as well a Design and supervision consultacy since it accured Halcrow internationals years ago especially in the region of United Arab Emirates. We are acting as professional designer, master planners as well a professional client advisor and representative through our project management consultancy division.

Q.2. What is your position within your organisation?

I am deputy Project Manager

Q.3. For how long your company has been practising as project management consultants?

Nearly 20 years in this region

Q.4. What is the average percentage for projects adapting BIM within overall running projects of your organisations' portfolio?

Most of our projects utilizing Building Information modeling technologies as we are the PMC mostly for the projects where are the designer as well.

Part two: of the interview questions was investigating current roles and responsibilities for project management consultants at each stage of the projects' life cycle. Accordingly, the following questions were asked of the interviewees:

Q.5. How do you describe stages of a project where your company services are usually provided?

The cycle of construction project starts with initiation of the project which is the feasibility study stag. Then it is followed by planning stage for procurement strategy which is also could be named as pre-design stage. The following stage is the design development stage. Then comes the construction stage which is followed by the handing over stage and operation stage. We do not get involved in the feasibility stage or operation stage but we provide services for all other stages

Q.6. At what stage usually project management consultants are hired by clients?

Usually at the pre- design stage, although in some cases we got appointed at later stage which is not for the best favor of the project.

Q.7. What is the role of the project management consultant at the pre-design stage?

What we do and what I would recommend doing is that during the pre-design stage, we need to provide assistance to the client to choose the designer. We also look at the commercial aspects of the contracts and manage the drafting. Risk management is a core aspect of this stage and it starts here so that we can do it systematically.

Q.8. How do you describe project management consultants' roles and responsibilities at design stage of project's life cycle?

Oh, here we have to make sure everything is going on systematically and in accordance with the clients requirements. The commercial aspect is important here and if there are design changes we need to manage that as well in terms of the commercial aspect. Here we also need to prepare for the construction stage like tender documents and prequalification of contractors.

Q.9. What are the roles of project management consultant at execution stage?

There are many probabilities with this stage to be honest. First we need to manage the design, and then the engineering drawing needs to be done properly. So here, it is crucial to manage the design differences and gaps between the model and engineering drawing to make sure that the project is not affected.

So before we start the construction, it is the role of the PMC to make sure that the client is satisfied. During the construction stage, we have to manage several aspects like procurement, engineering, risk, progress, and logistics. Here PMCS also do commercial management and oversee the cash flow as well. We PMCs also need to develop the process for payment certification with the contractors and consultants. Change management is a huge part of our role especially when it comes to commercial management.

We have no responsibility for safety or quality control, but we do manage it at a basic level.

Q.10. Should project management consultants be involved during the project handover stage and what would be their role?

Yes, we have to be involved during the handover stage as well. Primarily this will only be for commercial management and change management with regards to payments and what not.

Q.11. Should project management consultants be involved during the operation stage of the project lifecycle?

No, I don’t think that is necessary

Interview 3

Position: Projects Director

Q.1. How you describe the core business of your organisation?

KEO started and been operating for many years as an Architect and design & supervision firm. In the recently years with growing need in the industry for project management services; KEO has established its Project Management consultancy division which could operate independently or jointly with KEO Engineering and consulting.

Q.2. What is your position within your organisation?

I am projects director overlooking multi projects

Q.3. For how long your company has been practising as project management consultants?

Over 10 years

Q.4. What is the average percentage for projects adapting BIM within overall running projects of your organisations' portfolio?

Nearly half of our projects utilizing BIM which is mainly subject to clients requests.

Part two: of the interview questions was investigating current roles and responsibilities for project management consultants at each stage of the projects’ life cycle. Accordingly, the following questions were asked of the interviewees:

Q.5. How do you describe stages of a project where your company services are usually provided?

The known four stages where PMC could provide their services are pre-design, design, construction and handing over. There is not further involvement in the project during operation stage

Q.6. At what stage usually project management consultants are hired by clients?

Usually we got appointed at construction stage while we recommend having an early involvement at pre-design stage.

Q.7. What is the role of the project management consultant at the pre-design stage?

To ensure that all working parts are moving correctly. We help the clients choose the designers so that we are aware of the quality of the work. Commercial management like costing, change management are big aspects of this stage usually.

Q.8. How do you describe project management consultants' roles and responsibilities at design stage of project's life cycle?

This is an important stage of the project. The main function is to of course manage the design and ensure that it is being developed in accordance with the clients expectations. We also manage the progress of the design to ensure it gets completed on time. Risk management needs to be considered. Manage the tendering process and the commercial management has to be high level management. Program management is also part of this where we have to develop high level program management.

Q.9. What are the roles of project management consultant at execution stage?

We call it the construction stage and it is quite lengthy. I will try to go systematically. Design management is the first step and we have to manage it very carefully. We have to oversee the BIM practice as well here. Routine progress management and program management must be carried out involving procurement, engineering management, risk management, and commercial management. We also have to manage the change management process and provide safety recommendations along with overall quality recommendations.

Q.10. Should project management consultants be involved during the project handover stage?

Here, the commercial management is crucial. There should be no discrepancy between the cash flow and other financial aspects of the project. The handover should be smooth and also all the claims and everything needs to be settled.

Q.11. Should project management consultants be involved during the operation stage of the project lifecycle?

No

Interview 4

Position: Project Manager

Q.1. How you describe the core business of your organisation?

AECOM is an international organization specialized in design, engineering and master planning. Aecom has established its division for project management consultancy which operates independently or jointly with other division in the reorganization

Q.2. What is your position within your organisation?

Project Manager

Q.3. For how long your company has been practising as project management consultants?

Over 10 years already

Q.4. What is the average percentage for projects adapting BIM within overall running projects of your organisations' portfolio?

Around half of the projects where we are acting as PMC utilizing BIM

Part two: of the interview questions was investigating current roles and responsibilities for project management consultants at each stage of the projects' life cycle. Accordingly, the following questions were asked of the interviewees:

Q.5. How do you describe stages of a project where your company services are usually provided?

Preparation stage which could be called pre-design stage. Then the design followed by contruction stage and finally handing over the project to the owner.

Q.6. At what stage usually project management consultants are hired by clients?

Unfortunately in this region usually client hire PMC at beginning of construction stage while it is not ideal for the project.

Q.7. What is the role of the project management consultant at the pre-design stage?

In the predesign stage, we first provide commercial management, then we move onto the contract conditions recommendations, then we assist the clients in the pre-qualifications, tender process, etc. Here, we also provide designer recommendations and provide comments on the design.

Q.8. How do you describe project management consultants' roles and responsibilities at design stage of project's life cycle?

PMCs here have many functions. Starting from design management we carry out risk management and program management as well. In detail, we have to see design progress management and review the design to ensure that there is

Q.9. What are the roles of project management consultant at execution stage?

We manage the design at this stage. We need to ensure that the engineering drawing is prepared accurately and in timely manner from the designed model. We have to be the coordinators to ensure no gaps exist.

We also manage the progress and program. We do construction progress management, program management, procurement management, engineering management, logistics management and risk management as well. Commercial management like cash flow management and payment certification is also very crucial at this stage. Change management is also important part.

We provide recommendations for safety and quality but are not liable for the same.

Q.10. Should project management consultants be involved during the project handover stage?

Yes, to close everything systematically and settle all claims and variations

Q.11. Should project management consultants be involved during the operation stage of the project lifecycle?

No

Interview 5

Position: Project Director

Q.1. How you describe the core business of your organisation?

Faithful and Gold been operating for many years as a cost consultant organization. However; in the last decade with growing demand for professional and reliable project management services; Faithful and Gold established its Project management Consultancy division.

Q.2. What is your position within your organisation?

I am a project Director

Q.3. For how long your company has been practising as project management consultants?

Nearly 10 years

Q.4. What is the average percentage for projects adapting BIM within overall running projects of your organisations' portfolio?

Only few of our projects utilizing BIM technologies as it is mainly depend on clients decision

Part two: of the interview questions was investigating current roles and responsibilities for project management consultants at each stage of the projects' life cycle. Accordingly, the following questions were asked of the interviewees:

Q.5. How do you describe stages of a project where your company services are usually provided?

Pre-design, design, execution (construction), and handing over.

Q.6. At what stage usually project management consultants are hired by clients?

At design stage

Q.7. What is the role of the project management consultant at the pre-design stage?

This stage has many things. Commercial management is key. Then we have designer qualification, tendering, contract conditions change management, and also design recommendations.

Q.8. How do you describe project management consultants' roles and responsibilities at design stage of project's life cycle?

We oversee the design development and align it within the timeframe. Overall cash flow management and design change management. Risk management and construction stage preparation begins here like tender documents preparation as well as prequalification.

Q.9. What are the roles of project management consultant at execution stage?

Design translation from model to engineering drawing smoothly in accordance with guidelines. No design gaps and management of coordination issues. More important is management of progress and program which includes construction progress management, program management, procurement management, engineering management, logistics management and risk management. Commercial management also and it involves cash flow management and payment certification management.

Also engage in safety and quality recommendations.

Q.10. Should project management consultants be involved during the project handover stage?

Yes, of course. Settlement of payments and any variations is crucial here for the PMC

Q.11. Should project management consultants be involved during the operation stage of the project lifecycle?

No

Interview 6

Position: Project Director

Q.1. How you describe the core business of your organisation?

Turner Construction been operating a main contractor in USA since early 1900. The company decided to expand globally as parts of its growth plans. Outside Unites States of America; Turner Construction International operates as a Project Management Consultant to be one of early PMC in the region of GCC and UAE.

Q.2. What is your position within your organisation?

I am a director.

Q.3. For how long your company has been practising as project management consultants?

Over 20 years. As mentioned earlier; we have been one of the first project management companies in the region.

Q.4. What is the average percentage for projects adapting BIM within overall running projects of your organisations' portfolio?

Unfortunately only few of our projects utilizing BIM. We always been recommending our clients to adopt and allow for BIM in their projects as we are fully aware of all benefits for the client and the projects. However; most clients avoid changes to their comment practice unless they have to and they would use at minimal.

Part two: of the interview questions was investigating current roles and responsibilities for project management consultants at each stage of the projects' life cycle. Accordingly, the following questions were asked of the interviewees:

Q.5. How do you describe stages of a project where your company services are usually provided?

Commonly the known four stage: pre-design, design, construction and closing-out (handing over)

Q.6. At what stage usually project management consultants are hired by clients?

In this region it is common to hire PMC for construction stage after completion of design which is wrong concept by many clients.

Q.7. What is the role of the project management consultant at the pre-design stage?

See, we have to do the designer selection and design recommendations keeping in mind the client requirements. Also have to look at appropriate commercial management so that there are no issues with regards to the cash flow down the line. We need to be involved in the tender process as well.

Q.8. How do you describe project management consultants' roles and responsibilities at design stage of project's life cycle?

Its starts with design development and making sure it going properly and that the client is happy. We also have to look at the management of the commercial side of things, and risk management which is very important. In parallel we work on starting the construction stage and start preparing all the tender documentations etc.

Q.9. What are the roles of project management consultant at execution stage?

Design management can be considered as the opening of this stage. We make sure that the design meets client expectations as it is translated to engineering drawing. PMC's job here is to make sure that there are no gaps in the design to make sure design risk is managed properly.

The biggest part is program and progress management which includes program management, construction, procurement management, progress management, engineering management, logistics management and risk management.

Commercial management by way of cash flow management, and payment certifications for contractors and consultants are PMCs roles. We also involve ourselves a little bit in the quality and safety side as well. We have no liability but.

Q.10. Should project management consultants be involved during the project handover stage?

Yes. For managing the close out process. Also, we need to do commercial management as all claims and variation must be closed by the end of the project before handover.

Q.11. Should project management consultants be involved during the operation stage of the project lifecycle?

No

Interview 7

Position: Project Manager

Q.1. How you describe the core business of your organisation?

We are the project Management consultant for abu dhabi commercial bank

Q.2. What is your position within your organisation?

I am a projects manager overlooking various project under development by the client

Q.3. For how long your company has been practising as project management consultants?

Less than 10 years

Q.4. What is the average percentage for projects adapting BIM within overall running projects of your organisations' portfolio?

Unfortunately; BIM is not used within our projects.

Part two: of the interview questions was investigating current roles and responsibilities for project management consultants at each stage of the projects' life cycle. Accordingly, the following questions were asked of the interviewees:

Q.5. How do you describe stages of a project where your company services are usually provided?

Project initiation, pre-design, design, construction, close out.

Q.6. At what stage usually project management consultants are hired by clients?

Mostly construction stage when they have issues that they cannot fix. I think it should be earlier but as the problems will not arise if we are involved from the beginning.

Q.7. What is the role of the project management consultant at the pre-design stage?

Ideally, I would say pre-qualification and tendering. Also change management for cost related activities. Design recommendations as well will come in this stage.

Q.8. How do you describe project management consultants' roles and responsibilities at design stage of project's life cycle?

Usually, design is a major aspect of it. We need to make sure it is going well and in line with guidelines and expectations. We need to ensure that the commercial management is taking place well and we need to prepare for the next stages.

Q.9. What are the roles of project management consultant at execution stage?

Initially, we manage the design. See, design is already completed but we have to convert it now to engineering drawings. So to make sure there are no gaps or issues in design we need to be involved.

Then we management the construction progress management, program management, procurement management, engineering management, logistics management, risk management, and commercial management like cash flow and payment certification.

Safety and quality control also requires just cursory involvement.

Q.10. Should project management consultants be involved during the project handover stage?

Yes, to manage claims and variation before the close out process.

Q.11. Should project management consultants be involved during the operation stage of the project lifecycle?

No

Interview 8

Position: Project Director – Head of Business Development

Q.1. How you describe the core business of your organisation?

We are a [project Management Consultants and client representatives

Q.2. What is your position within your organisation?

I am the head of business development

Q.3. For how long your company has been practising as project management consultants?

Less than 10 years

Q.4. What is the average percentage for projects adapting BIM within overall running projects of your organisations' portfolio?

Unfortunately; none of our project utilizing BIM although we strongly believe in the benefits of utilizing such techniques and solution. However; in this part of the world it is left for the client to decide if they are willing to use BIM or not in their projects.

Part two: of the interview questions was investigating current roles and responsibilities for project management consultants at each stage of the projects' life cycle. Accordingly, the following questions were asked of the interviewees:

Q.5. How do you describe stages of a project where your company services are usually provided?

Pre-design, design, construction and closing out

Q.6. At what stage usually project management consultants are hired by clients?

Commonly at construction stage only which is late and not ideal practice

Q.7. What is the role of the project management consultant at the pre-design stage?

I think it needs to involve commercial management at an intermediate level and the design evaluations and such at an intermediate level. I also assume the PMC should be involved in qualifying the designer and making design recommendations in accordance with the client's expectations. Managing client expectations is very important at this stage and all stages.

Q.8. How do you describe project management consultants' roles and responsibilities at design stage of project's life cycle?

One, design development in line with clients directions. Commercial and change management in small capacity, manage early risk and set the stage for start of next steps like tendering and pre-qualification.

Q.9. What are the roles of project management consultant at execution stage?

So many things we do here in this stage. Design is very important. We have to make sure that the engineering drawing that is being rendered or already rendered is in line with design. Design is a major aspect.

The next step is to manage the commercial aspect like cash flow and payment certification. Then program management which is a combination of construction progress management, program management, procurement management, engineering management, logistics management and risk management.

Q.10. Should project management consultants be involved during the project handover stage?

Yes. We should be.

Q.11. Should project management consultants be involved during the operation stage of the project lifecycle?

No.

Interview 9

Position: Project Manager

Q.1. How you describe the core business of your organisation?

Atkins a an international design consultancy specialized in various finds of projects from infrastructure, roads, master planning and buildings. In the recent years we have established the project management consultancy department in the organization which could operate independently or jointly with other departments.

Q.2. What is your position within your organisation?

Manager

Q.3. For how long your company has been practising as project management consultants?

Between 10 and 20 years

Q.4. What is the average percentage for projects adapting BIM within overall running projects of your organisations' portfolio?

For the PMC practice; only few of the projects would utilize BIM technologies

Part two: of the interview questions was investigating current roles and responsibilities for project management consultants at each stage of the projects' life cycle. Accordingly, the following questions were asked of the interviewees:

Q.5. How do you describe stages of a project where your company services are usually provided?

Pre-design, design, construction and closeout

Q.6. At what stage usually project management consultants are hired by clients?

Usually at construction stage which is not ideal as we would serve the project better at pre-design stage. Maybe because most of the project we practice PMC are the same projects designed by our company.

Q.7. What is the role of the project management consultant at the pre-design stage?

Contract conditions need to be reviewed, then tender process should be managed, then the commercial management should start and we should also be involved in the design recommendations.

Q.8. How do you describe project management consultants' roles and responsibilities at design stage of project's life cycle?

We carry out the design management. Meaning we oversee the design process and make sure that the designers are following the specifications and doing everything according to the client expectations. Early risk management begins from pre-design and moves to this stage. We also involve ourselves into commercial management and make sure that from the start itself the costing and cash flow is managed properly. Some PMCs also begin planning for the next stage like doing the tendering and prequalification documents.

Q.9. What are the roles of project management consultant at execution stage?

Design management, design management, design management. Very impotant to make sure that it is all in line with client needs. The render to engineering drawing should not have any gaps otherwise client is unhappy and risk is more.

Program management after design management like procurement, logistics, engineering, program, construction progress, and risk management.

Then is commercial management where we manage the cash flow of the task and certifying payments for contractors and consultants. Change control and management. Safety and quality recommendations for project as an advisory role.

Q.10. Should project management consultants be involved during the project handover stage?

Yes. Our role for handing over stage will be managing the close out process. Also, commercial management as all claims and variation must be closed by the end of the project

Q.11. Should project management consultants be involved during the operation stage of the project lifecycle?

No

Interview 10

Position: Project Director

Q.1. How you describe the core business of your organisation?

We are a design and supervision consultancy majored in infrastructure project in the region. Recently we have added a division for project management services

Q.2. What is your position within your organisation?

I am project Director

Q.3. For how long your company has been practising as project management consultants?

More than 10 years in this region

Q.4. What is the average percentage for projects adapting BIM within overall running projects of your organisations' portfolio?

BIM is used in few projects only

<u>Part two:</u> of the interview questions was investigating current roles and responsibilities for project management consultants at each stage of the projects' life cycle. Accordingly, the following questions were asked of the interviewees:

Q.5. How do you describe stages of a project where your company services are usually provided?

Pre-design stage followed by design stage. Then execution stage which is contrition and finally closing out stage which could be called handing over stage as we handover the delivered asset to the owners' appointed operator.

Q.6. At what stage usually project management consultants are hired by clients?

Usually write prior start of construction

Q.7. What is the role of the project management consultant at the pre-design stage?

We have commercial management, design recommendations, pre-qualification and tendering, contract conditions, and designer selection.

Q.8. How do you describe project management consultants' roles and responsibilities at design stage of project's life cycle?

Design management, commercial management, risk management in small amounts, and managing client expectations. Preparing for construction stage by doing pre-qualification and tendering.

Q.9. What are the roles of project management consultant at execution stage?

So many functions. Design management and making sure its all done on time and with clients approval timely. Design is completed before but we have to coordinate the translation into engineering drawing.

Program and progress management is also important. Things like risk management, procurement and logistics management, program management, and progress as well. Here, we also do commercial

Q.10. Should project management consultants be involved during the project handover stage?

Yes, for closing everything and smooth handover.

Q.11. Should project management consultants be involved during the operation stage of the project lifecycle?

No

Interview 11

Position: Project Manager

Q.1. How you describe the core business of your organisation?

We are a project management Consultants organization

Q.2. What is your position within your organisation?

Project Manager

Q.3. For how long your company has been practising as project management consultants?

More than 10 years

Q.4. What is the average percentage for projects adapting BIM within overall running projects of your organisations' portfolio?

Unfortunately only some of our projects.

<u>Part two:</u> of the interview questions was investigating current roles and responsibilities for project management consultants at each stage of the projects' life cycle. Accordingly, the following questions were asked of the interviewees:

Q.5. How do you describe stages of a project where your company services are usually provided?

While projects stages are mainly the pre-design, design, construction and handing over; we get appointed in different stages depends on projects conditions.

Q.6. At what stage usually project management consultants are hired by clients?

Mostly at design stage.

Q.7. What is the role of the project management consultant at the pre-design stage?

Designer review and recommendation, pre-qualification and tendering process. We also are involved in commercial management.

Q.8. How do you describe project management consultants' roles and responsibilities at design stage of project's life cycle?

Usually we do design management, manage the commercial aspects of it, and also engage in risk management which is already ongoing. Many times we also start with the development of the tendering documentation and pre-qualification to prepare for the construction stage.

Q.9. What are the roles of project management consultant at execution stage?

When the contractor does the design, we have to be the coordinators and ensure that there are no gaps between the design and engineering drawing. We have to oversee the commercial management and program management. Smaller aspects such as logistics, procurement, engineering, progress, change, and cost management.

Q.10. Should project management consultants be involved during the project handover stage?

Yes we need to be.

Q.11. Should project management consultants be involved during the operation stage of the project lifecycle?

Yes, I think so. We need to be involved in the operations as well.

Interview B

Respondent 1

Q.1. Do you believe that involving PMC in the BIM process would add value to <u>the project</u>?

Yes, it will. I think it we should be involved from the pre-design stage to make sure that the EIR is accurate.

Q.2. Do you believe that involving PMC in the BIM process would add value to <u>the PMC team</u> and their role?

Yes, indeed it would

Q.3. In your opinion what would be a new role for PMC pertaining BIM at each stage within the project life cycle?

I think the role of PMC should be made from pre-design to handing over stage. It’s important that the PMC should be involved from the pre-design stage.

Q.4. In your opinion; how should BIM integrate into current functions and tasks of the pre-design stage?

Pre-design stage, PMC should review available Employer information requirements (EIR) and comment on it and to provide necessary recommendation for amendments. If an EIR is not exist by the client; then the PMC should assist the client developing the EIR.. We should also be involved in making the project strategy for BIM and draft the BIM scope for designer and contractors and to make sure it is included in the tender documentation.

Q.5. In your opinion; how should BIM integrate to current functions and tasks of the design stage?

I think there are three things that we need to do as PMCs. First, ensure that the designer BEP is approved and is compliant with the BIM scope and strategy. Next, we need to guide the BIM development and management process to make sure that the final BIM model is developed accurately. Finally, we need to be involved in regular meetings to discuss the changes and also make sure that the Contractors’ BIM prequalification are finalized.

Q.6. In your opinion; how should BIM integrate to current functions and tasks of the construction stage?

First we should review and approve contractors BIM execution plan. We need to be involved to make sure that the BIM development is managed properly and that the contractors BIM construction deliverables are submitted. We need to ensure that the technical and non-technical review of BIM is approved and we also need to be in important and necessary meetings with the Internal and External stakeholders.

Q.7. In your opinion; how should BIM integrate to current functions and tasks of handing over stage?

First we need to review the submitted final BIM deliverables from a technical standpoint. Next we need to coordinate with the final end users to make sure that the handing over process is as smooth as possible. Then finally the BIM deliverables will be taken over by the client.

Respondent 2

Q.1. Do you believe that involving PMC in the BIM process would add value to <u>the project</u>?

Yes.

Q.2. Do you believe that involving PMC in the BIM process would add value to <u>the PMC team</u> and their role?

Yes

Q.3. In your opinion what would be a new role for PMC pertaining BIM at each stage within the project life cycle?

Pre-design

Q.4. In your opinion; how should BIM integrate into current functions and tasks of the pre-design stage?

Review available Employer information requirements. Make changes if required. If EIR is not there, then PMC will help the client to develop it. Finalize the EIR and draft the BIM project strategy. Then develop the BIM scope of the designer and the contractor. After that, review the BIM section in designer prequalification for tender.

Q.5. In your opinion; how should BIM integrate to current functions and tasks of the design stage?

Approve designer BEP and BXP. Oversee the BIM development process by the design team.

The third task will be to Manage the BIM section in the contractors prequalification for tender.

Q.6. In your opinion; how should BIM integrate to current functions and tasks of the construction stage?

Finalize the BIM execution plan. First task will be to review and approve the contractors BEP or BXP. The second task will be to manage the BIM implementation for construction. The third aspect will be to manage the collaboration between the stakeholders.

Q.7. In your opinion; how should BIM integrate to current functions and tasks of handing over stage?

Handing over must be really smooth. All deliverables must be handed over to client. And PMC should manage the entire process of BIM deliverables handing over

Respondent 3

Q.1. Do you believe that involving PMC in the BIM process would add value to <u>the project</u>?

For sure it will. I think it we should be involved from the pre-design stage to make sure that the EIR is accurate. You know we have to review the EIR and recommend changes and all so better to be involved from pre-design stage. Also will prevent long terms issues.

Q.2. Do you believe that involving PMC in the BIM process would add value to <u>the PMC team</u> and their role?

Yes

Q.3. In your opinion what would be a new role for PMC pertaining BIM at each stage within the project life cycle?

I think the role of PMC should be from pre-design to handing over stage. It's important that the PMC should be involved from the pre-design stage to make sure everything is taking place well from the very start of the project.

Q.4. In your opinion; how should BIM integrate into current functions and tasks of the pre-design stage?

We should develop the EIR if it's not there and review and recommend any changes to it. If the EIR is finalized then it will be PMCs job to start the BIM strategy with the newest EIR and ensure that it is approved by the client. On the side, we also need to start the pre-qualifications in the designers proposals. It's also our job to draft the BIM scope for the designer an contractors and ensure it is added to the tender documentation.

Q.5. In your opinion; how should BIM integrate to current functions and tasks of the design stage?

When the designers provide the BEP, we need to review it against the scope of the project and check for strategic alignment. If there is no alignment, we need to initiate the updating process until it is approved. Once done, the designer can send across the BIM models and our work can commence from there for managing the BIM development process and reviewing the BIM models submissions and managing the regular progress meetings.

Q.6. In your opinion; how should BIM integrate to current functions and tasks of the construction stage?

When the contractors issue the BEP, we need to be involved to make sure that the BIM development is managed properly. There needs to be a review of the same against the BIM scope and Strategy. Then when the contractors submit BIM construction deliverables, we need to ensure that the technical and non-technical review of BIM is carried out and approved. Also, we also need to be in important and necessary meetings with the Internal and External stakeholders.

Q.7. In your opinion; how should BIM integrate to current functions and tasks of handing over stage?

First, we need to review the submitted final BIM deliverables technically. Then, we have to synchronize with the final end users to make sure that the handing over process is as smooth as possible. Then finally the BIM deliverables will be given to the client.

Respondent 4

Q.1. Do you believe that involving PMC in the BIM process would add value to the project?

Yes and doing so will eliminate issues that usually arise later.

Q.2. Do you believe that involving PMC in the BIM process would add value to the PMC team and their role?

Of course it will

Q.3. In your opinion what would be a new role for PMC pertaining BIM at each stage within the project life cycle?

Pre-design stage

Q.4. In your opinion; how should BIM integrate into current functions and tasks of the pre-design stage?

First, reviewing and recommendation of the EIR and drafting of the project BIM strategy. If no EIR, then we develop and then finalize it. The second, the drafting of the BIM scope of the designer and the contractor. The third, the review of the BIM section in designer prequalification for tender. Also outline BIM scope for designer and contractor and get it included in tender documents.

Q.5. In your opinion; how should BIM integrate to current functions and tasks of the design stage?

First task can be review and approval of the designers BEP and BXP. Second task will be to oversee the BIM development process by the design team and ensure everything is properly aligned. The third task will be to analyse the BIM section in the contractors prequalification for tender.

Q.6. In your opinion; how should BIM integrate to current functions and tasks of the construction stage?

First task will be to review and approve the contractors BEP or BXP. The second task will be to manage the BIM implementation for construction. The third aspect will be to manage the collaboration between the stakeholders.

Q.7. In your opinion; how should BIM integrate to current functions and tasks of handing over stage?

PMC should manage the process of BIM deliverables handing over while the technical reviews of deliverables would be by supervision consultant and client operation department

Respondent 5

Q.1. Do you believe that involving PMC in the BIM process would add value to <u>the project</u>?

Yes I strongly believe so.

Q.2. Do you believe that involving PMC in the BIM process would add value to <u>the PMC team</u> and their role?

Yes, one hundred percent.

\Q.3. In your opinion what would be a new role for PMC pertaining BIM at each stage within the project life cycle?

Pre-design is crucial to be included. Many times OMC is involved from construction stage and they spend a lot of time rectifying old issues. This can be avoided if we are involved from the start.

Q.4. In your opinion; how should BIM integrate into current functions and tasks of the pre-design stage?

EIR review should be included and integrated as core function. PMC should develop the draft for the BIM and project strategy and making sure that it is all incorporated in the tender documents.

Q.5. In your opinion; how should BIM integrate to current functions and tasks of the design stage?

Finalize the EIR first by reviewing what is available and making changes to it. If EIR is not available we have to make it. The PMC needs to review and approve the designers BEP or BXP and should make the strategy and BIM scope. Final BIM model needs to be developed by the PMC here and they need to arrange regular meetings to discuss any changes. This will also help to finalize the contractor prequalifications.

Q.6. In your opinion; how should BIM integrate to current functions and tasks of the construction stage?

The BIM and the project needs to be technically reviewed by supervision consultant while the process itself managed by PMC. at this stage and PMC needs to coordinate with internal stakeholders and external stakeholders. Beside ensuring best implementation of BIM uses at construction stage inline with scope requirements and project strategy

Q.7. In your opinion; how should BIM integrate to current functions and tasks of handing over stage?

Make sure that the BIM deliverables are submitted and the handing over process is smooth and efficient while the technical reviews are by client operations department as well supervision consultant.

Respondent 6

Q.1. Do you believe that involving PMC in the BIM process would add value to the project?

Without a doubt it will. I figure it PMC ought to be included from the pre-design stage to ensure that the EIR is proper. You realize the PMC needs to study the EIR and prescribe changes so better to be included from pre-design stage. Additionally, will avert long terms issues.

Q.2. Do you believe that involving PMC in the BIM process would add value to the PMC team and their role?

Truly

Q.3. In your opinion what would be a new role for PMC pertaining BIM at each stage within the project life cycle?

I think the job of PMC ought to be from pre-design to handing over stage. It's vital that the PMC be included from the pre-design stage to ensure everything is occurring in a systematic manner from the very beginning of the undertaking.

Q.4. In your opinion; how should BIM integrate into current functions and tasks of the pre-design stage?

The PMC ought to build up the EIR and analyze it and prescribe any improvements to it. On the off chance that the EIR is approved, it will be PMCs responsibility to initiate the BIM process with the most up to date EIR and ensure that it is validated by the customer. As an afterthought, the PMC additionally needs to begin the pre-qualifications for designers also. They need to also make sure that the BIM strategy and scope of work is provided to the designers and contractors.

Q.5. In your opinion; how should BIM integrate to current functions and tasks of the design stage?

At the point when the designers give the BEP, we have to appraise it against the extent of the undertaking and check for agreement. On the off chance that there is no arrangement, The PMCs have to start the procedure again until it is finalized. When done, the designer can send over the BIM models and PMCs work can start from that point for dealing with the BIM process and assessing the BIM models entries. And definetlly the PMC must review and approved the BEP submitted by designer at the beginning of design stage.

Q.6. In your opinion; how should BIM integrate to current functions and tasks of the construction stage?

PMC should develop or review existing EIR At the point when the contractors issue the BEP, they should be included to ensure that the BIM improvement is overseen in a timely manner. There should be an audit of the equivalent against the BIM model and project scope. At that point when the contractors submit BIM development expectations, PMCs have to guarantee that the technical and non-technical survey of BIM is done and validated. Likewise, they need to organize important meetings with the Internal and External partners. Additionally, Ensuring that BIM been used as desired for construction stage for other uses like 4D and 5D.

Q.7. In your opinion; how should BIM integrate to current functions and tasks of handing over stage?

To begin with, PMC has to survey the submitted last BIM expectations actually. At that point, they need to synchronize with the clients to ensure that the handing over process is as smooth as would be possible. At that point at long last the BIM expectations will be given to the customer.

Respondent 7

Q.1. Do you believe that involving PMC in the BIM process would add value to <u>the project</u>?

Yes and doing so will eliminate issues that usually arise later.

Q.2. Do you believe that involving PMC in the BIM process would add value to <u>the PMC team</u> and their role?

Yes

Q.3. In your opinion what would be a new role for PMC pertaining BIM at each stage within the project life cycle?

I think better to include pre-design as I think that's more important and one where usually PMC is not involved.

Q.4. In your opinion; how should BIM integrate into current functions and tasks of the pre-design stage?

First thing can be the reviewing and recommendation of the EIR and drafting of the project BIM strategy. The second thing will be the drafting of the BIM scope of the designer and the contractor. The third aspect will be the review of the BIM section in designer prequalification for tender. The PMC can also be involved in the development of the BIM scope for designers and contractors.

Q.5. In your opinion; how should BIM integrate to current functions and tasks of the design stage?

First task can be review and approval of the designers BEP and BXP. Second task will be to oversee the BIM development process by the design team and ensure everything is properly aligned. The third task will be to analyse the BIM section in the contractors prequalification for tender.

Q.6. In your opinion; how should BIM integrate to current functions and tasks of the construction stage?

First task will be to review and approve the contractors BEP or BXP. The second task will be to manage the BIM implementation for construction. The third aspect will be to manage the collaboration between the stakeholders.

Q.7. In your opinion; how should BIM integrate to current functions and tasks of handing over stage?

Managing the process to ensure smooth handing over process for all BIM deliverables.

Respondent 8

Q.1. Do you believe that involving PMC in the BIM process would add value to <u>the project</u>?

Truly, it will. I figure it we ought to be included from the pre-design stage to ensure that the EIR is exact.

Q.2. Do you believe that involving PMC in the BIM process would add value to <u>the PMC team</u> and their role?

Truly, surely it would

Q.3. In your opinion what would be a new role for PMC pertaining BIM at each stage within the project life cycle?

I think the job of PMC ought to be produced using pre-plan to giving over stage. It's vital that the PMC ought to be included from the pre-structure arrange.

Q.4. In your opinion; how should BIM integrate into current functions and tasks of the pre-design stage?

In the Pre-design stage PMC ought to be the one to build up the EIR and audit it and ensure everything is precise. They should to likewise be associated with making the technique for BIM and PMC and guaranteeing that it is incorporated into the tender documentation. Making BIM scope and strategy for the designers and contractors is crucial.

Q.5. In your opinion; how should BIM integrate to current functions and tasks of the design stage?

I think there are three things that they have to do as PMCs. In the first place, guarantee that the BEP is endorsed and is consistent with the BIM degree and technique. Next, we have to control the BIM improvement and the board procedure to ensure that the last BIM show is created precisely. At long last, we should be associated with customary gatherings to talk about the progressions and furthermore ensure that the Contractors' BIM prequalification are concluded.

Q.6. In your opinion; how should BIM integrate to current functions and tasks of the construction stage?

They should be included to ensure that the BIM improvement is overseen appropriately and that the contractual workers BIM development expectations are submitted. That accures through review and approve BEP. They have to guarantee that the specialized and non-specialized audit of BIM is affirmed, and they likewise should be in essential and vital gatherings with the Internal and External partners.

Q.7. In your opinion; how should BIM integrate to current functions and tasks of handing over stage?

First They have to survey the submitted last BIM expectations from a specialized stance. Next PMCs have to arrange with the last end clients to ensure that the giving over process is as smooth as would be prudent. At that point at last the BIM expectations will be assumed control by the customer.

Respondent 9

Q.1. Do you believe that involving PMC in the BIM process would add value to <u>the project</u>?

Yes from the pre-design to ensure beyond any doubt that the EIR is exact.

Q.2. Do you believe that involving PMC in the BIM process would add value to <u>the PMC team</u> and their role?

Yes, of course

\Q.3. In your opinion what would be a new role for PMC pertaining BIM at each stage within the project life cycle?

I think the role of PMC should be made from pre-design to handing over stage. Pre-design is crucial to be included.

Q.4. In your opinion; how should BIM integrate into current functions and tasks of the pre-design stage?

The PMC must develop EIR as well as review it and make changes and ensure everything is precise. The PMC also be involved in drafting the plan for BIM and PMC and guaranteeing that it is included in the tender documentation. Also developing the scope and BIM strategy is important.

Q.5. In your opinion; how should BIM integrate to current functions and tasks of the design stage?

The PMC needs to certify that the BEP is approved and is accommodating the BIM scope and strategy. PMC needs to manage the BIM development and management process to make sure that the final BIM model is developed accurately. Finally, PMCs need to be involved in regular meetings to discuss the changes and also make sure that the Contractors' BIM prequalification are finalized.

Q.6. In your opinion; how should BIM integrate to current functions and tasks of the construction stage?

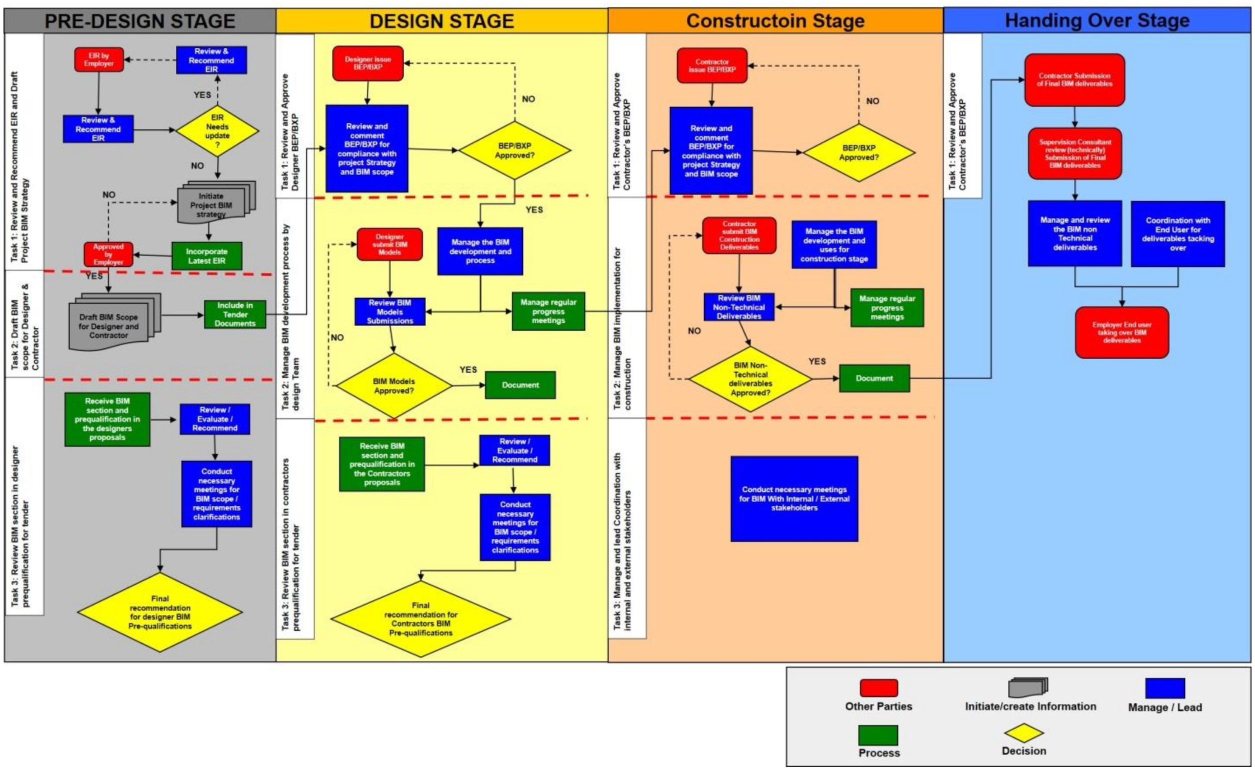
Managing the contractor so that the BIM construction deliverables are develop properly and submitted on time. BIM needs to be technically reviewed in this stage along with non-technical review. Then PMC needs to coordinate between the stakeholders.

Q.7. In your opinion; how should BIM integrate to current functions and tasks of handing over stage?

Submit the final BIM deliverables in a technical manner. Then collaborate and arrange the final users to make sure that the handing over process is as smooth as possible. Then allow the BIM deliverables to be taken over by the client.

Interview C: Validation

The research was carried out in three stages. The first stage involved interviewing 11 senior level Project Directors and Managers to uncover the current PMC practices in the UAE. Following this, 9 BIM professionals (5 BIM Managers selected from PMC Organizations, 2 BIM Managers from Design Consultancy firms, and 2 BIM Managers from Contractors firms) were interviewed and a framework was developed. A detailed discussion was held with each of the participants and each of the stages and tasks were discussed at length.



Kindly examine the framework in detail and provide your thoughts on the accuracy of the same. If you do not agree, kindly provide an alternative and a reason for the same. Please review each task in detail.

Responses:

PMC1: It looks good and it is comprehensive and covers everything. All the stages and the subsequent tasks are well aligned and fit with the industry expectations.

PMC2: Oh, this is great. It is fully developed and has all the stages in detail. I have no disagreements. All the tasks in the stages are what we need to do. It's good that you have unified everything and addressed all areas that PMCs need to be involved in.

PMC3: I agree with it. I agree with all the stages and don't think it's necessary to add anything else.

PMC4: I agree with it and it's a good framework. But I also believe that we need to be involved after the handing over stage during the operations.

Contractor1: No, this framework covers everything and is good. I wish all the PMCs start doing all of this from beginning to end. It will really streamline the processes.

Contractor2: I have gone through this in detail and I feel that this is comprehensive and covers everything.

Consultant 1: I agree with all the stages and the details. All the stages and the tasks are well developed. I think this is a great thing to apply in the industry as it will reduce some of the feelings of uncertainty. It will also increase the way PMC is organized and does work.

Consultant 2: I have to say this is great. Comprehensive, easy to understand and follow. No need to add anything else.

Client1: I have never seen such a framework before and if the work is done using this, it will be very good and finish faster and systematically.

Cleint2: I think this is great. Especially seeing if this is used by all PMCs and clients most of the issues that come with construction will be eliminated. Maybe we can see projects being completed on time for once after the framework is used. Very good. I agree with all of this.